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Response Action Work Plan
Libby Asbestos Project
Libby, Montana

April 2007

DCN: DC2616.012.202.HANDS-2216.00

Revision 1

Prepared for:

U. S. EPA Region 8
1595 Wynkoop Street
Denver, Colorado 80202-1129

Prepared by:

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Research and Innovative Technology Administration
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One Cambridge Place
50 Hampshire Street
Cambridge, Massachusetts 02319

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Contents

Figures

Acronyms and Abbreviations

A&E	architectural and engineering firm
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACM	asbestos-containing material
AHA	activity hazard analysis
AHERA	Asbestos Hazard Emergency Response Act of 1986
AMS	Agricultural Marketing Service
ANLA	American Nursery and Landscape Association
ANSI	American National Standards Institute
ARM	Administrative Rules of Montana
ASTM	American Society for Testing Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWWA	American Water Works Association
bgs	below ground surface
BMP	best management practices
BOCA	Building Officials and Code Administrators
BZ	breathing zone
CDM	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CIC	community involvement coordination
CRSI	Concrete Reinforcing Steel Institute
CRZ	contamination reduction zone
CSHASP	Comprehensive Site Health and Safety Program
DAR	final draft design analysis report
DEQ	Department of Environmental Quality
DOT	U. S. Department of Transportation
EC	electrical conductivity
eLASTIC	electronic Libby Asbestos Sample Information Tracking
EPA	U. S. Environmental Protection Agency
ERRS	Emergency Rapid Response Services
EZ	exclusion zone
F	Farenheit
ft^3	cubic feet
GFCI	ground fault circuit interrupter
GPS	global positioning system
H&S	health and safety
HEPA	high efficiency particulate air
hp	horsepower
HVAC	heating, ventilating, and air conditioning
IAG	inter-agency agreement
IBDU	isobutylenediurea
LA	Libby amphibole
lbs	pounds
LO/TO	lockout/tagout

LV	Libby Vermiculite
MCA	Montana Code Annotated
meq	milliequivalents
mmhos	micromhos
MSDS	material safety data sheet
MSHA	Mine Safety and Health Administration
MSP	Manual of Standard Practice
NEMA	National Electrical Manufacturers Association
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NPE	negative pressure enclosure
NRMCA	National Ready Mixed Concrete Association
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PCM	phase-contrast microscopy
PDIWP	final draft pre-design inspection work plan
PDI	pre-design inspection
POCV	point-of-cut-ventilated
PPE	personal protective equipment
psi	pounds per square inch
QA	quality assurance
QC	quality control
R-value	thermal resistance value
RAWP	response action work plan
RAWP SAP	response action sampling and analysis plan
RITA	Research and Innovative Technology Administration
RFP	request for proposal
SAP	sampling and analysis plan
SAR	sodium absorption ratio
SHSO	site health and safety officer
SSHASP	site-specific health and safety plan
SSVR	small scale vermiculite removal
STEL	short-term exposure limit
TEM	transmission electron microscopy
TMMB	Truck Mixer Manufacturers Bureau
TWA	time weighted average
VCI	vermiculite-containing insulation
Volpe Center	John A. Volpe National Transportation Systems Center
w/c	water to cement ratio
wr	water reducing admixture
yd^3	cubic yards

Section 1
Introduction

The U. S. Environmental Protection Agency (EPA), Region 8, is conducting response actions at residential, commercial, and industrial properties located in Libby, Montana, to address the risk to human health caused by exposure to Libby amphibole (LA) asbestos. LA asbestos exists in a variety of sources, such as soil, vermiculite-containing insulation (VCI), and interior dust. This Response Action Work Plan (RAWP) outlines the approach to conducting the removal of these sources.

1.1 Inter-Agency Agreement

Through an inter-agency agreement (IAG), the U. S. Department of Transportation (DOT), Research and Innovative Technology Administration (RITA), John A. Volpe National Transportation Systems Center (Volpe Center) is providing environmental engineering and removal support to EPA. Support activities include procuring removal and other contractors, preparing response action plans and designs, conducting response actions, providing response action construction management, and preparing technical studies and reports. Currently, the Volpe Center is providing support for the removal of LA asbestos-contaminated materials at properties located in Libby, Montana (hereafter referred to as the Libby Project).

1.2 Document Purpose

The purpose of this RAWP is to describe the technical requirements of the Libby Project, define roles and responsibilities of all Libby Project resources (i.e., EPA, Volpe Center, and their contractors, collectively referred to as the Libby Team), and to serve as a guidance document for the Libby Project as it proceeds. Each property in Libby is unique and may also require site-specific changes or modifications to the response actions described in this document. A site-specific RAWP Addendum and its associated contract drawings (hereafter collectively referred to as a site-specific work plan) will be prepared for each property requiring removal activities. The site-specific work plan will detail the extent of contamination, required removal activities, and restoration plans. The site-specific work plan will be reviewed and agreed upon by the property owner and representatives of the Volpe Center, EPA, architectural and engineering firm (A&E), and the removal contractor before remediation activities commence.

The RAWP includes two appendices: Appendix A, Response Action Sampling and Analysis Plan for the Libby Asbestos Site (RAWP SAP), and Appendix B, containing Construction Specifications and A&E Air Monitoring Frequencies. These appendices supplement information contained within Sections 1 through 10, and are an integral part of the overall document.

The RAWP complements documents prepared by EPA, Volpe, and the A&E that detail other aspects of residential and commercial cleanup in Libby. Other documents include the Final Draft Pre-Design Inspection Work Plan (PDIWP) (CDM 2003b), Final Draft Design Analysis Report (DAR) (CDM 2003a), EPA Action Level and Clearance Criteria Technical Memorandum (EPA 2003a), Comprehensive Site Health and Safety Program

(CSHASP) (CDM 2006), Dust Sampling and Analysis Plan (EPA 2003b), and High Efficiency Particulate Air (HEPA) Vacuum Program Memorandum (Volpe 2003).

As necessary, this RAWP will be modified to reflect EPA requirements and changes in the scope of the project. Modifications will be documented via the site-specific work plans.

1.3 Background

The City of Libby is located in northwestern Montana, approximately 25 miles east of the Idaho border and 40 miles south of the Canadian border, situated within the Kootenai River Valley, just north of the Cabinet Mountain Range (Figure 1-1). The residential and commercial sites are located in and near the city of Libby, Montana (Figure 1-2). Libby is the site of the former largest vermiculite mine in the world, which had been operational for 70 years. In the 1920s, the Zonolite Company formed and began mining vermiculite. In 1963, W.R. Grace bought the Zonolite mining operations. The mine closed in 1990. While in operation, the vermiculite mine in Libby may have produced 80 percent of the world's supply of vermiculite. Vermiculite has been used in building insulation, building aggregate, and as a soil conditioner. It has been determined that the vermiculite from the Libby mine was contaminated with naturally occurring asbestos, a solid solution series of asbestiform mineral fibers that includes tremolite, actinolite, winchite, and richterite. For convenience, this solid solution series is herein referred to as LA.

In response to local concern and news articles regarding asbestos-contaminated vermiculite, the EPA sent an emergency response team to Libby, Montana, in late November 1999. In December 1999, the EPA team collected nearly 700 samples (air, soil, dust, and bulk insulation). In January 2000, EPA released the indoor air sample results to property owners and eventually to the media and general public. Through additional sampling, these response actions have grown to include remediation activities at various former vermiculite processing areas, as well as commercial and residential properties.

EPA is currently conducting response actions in Libby using removal authority under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), allowing the agency to quickly evaluate and remediate contaminated properties.

1.4 Quality Assurance

The Libby Team has established a formal quality assurance (QA) program to ensure consistent high quality project deliverables. All removal action work performed by the A&E under the RAWP is conducted in accordance with quality procedures described in the A&E's *Quality Assurance Manual* (CDM 2002).

Technical proposals and work plans require a QA section. A member of the A&E QA staff has prepared this RAWP section and will maintain QA oversight for the duration of the work conducted under the RAWP.

File maintenance, storage, and control for all original remedial action field documentation, with the exception of logbooks, is conducted at the A&E field office in Libby, Montana. File maintenance, storage, and control of logbooks and copies of field documentation are maintained at the A&E office in Denver, Colorado. Project documentation produced by the A&E is indexed and tracked by the Libby file administrator. Copies of all relevant documents will be provided to the Volpe Center on a periodic basis as identified by the Volpe Center project manager. Electronic data is ultimately stored in the Libby2 project database, which is housed on a secure EPA server in Denver, Colorado and managed by the Volpe Center database manager. In addition, limited data is entered into the electronic Libby Asbestos Sample Tracking Information Center (eLASTIC) and Property Closeout Checklist databases in Libby, Montana and provided to the Volpe Center database manager electronically by the A&E sample coordinator and A&E administrative staff, respectively. Maintenance of project databases is provided by A&E database support personnel, with Volpe Center consultation. Details regarding project data storage are included in the RAWP SAP.

The QA program includes both self-assessments and independent assessments as checks on the quality of the data and reports produced during this task order. The A&E QA manager determines the frequency of field and office audits. Office and field audits will each be performed at least once per 12-month period or more frequent, if requested by the Volpe Center project manager.

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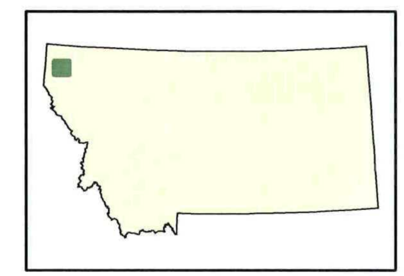
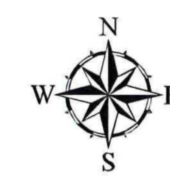
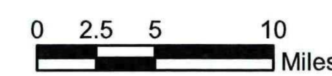
Figure 1-1
Site Location Map
Libby Asbestos Site
Lincoln County, Montana

Legend

- Highway
- County Boundary
- Roads
- Railroad
- Approximate Site Boundary
- Water
- City







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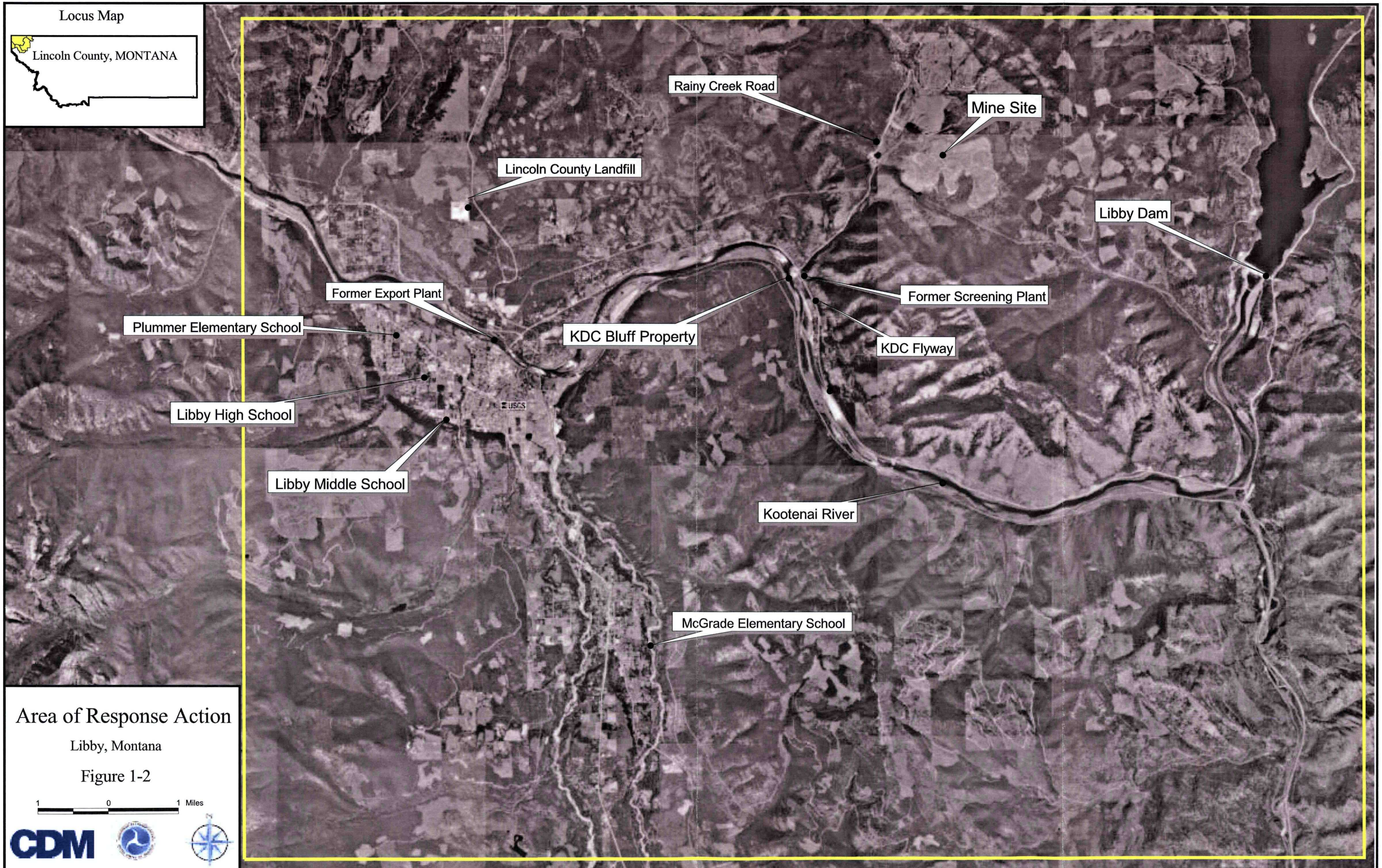

Area of Response Action

Libby, Montana

Figure 1-2

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Section 2
Roles and Responsibilities

The Libby Project team consists of EPA, the Volpe Center, the A&E, the removal contractors, and other contractors. The roles and responsibilities of these team members follow.

2.1 EPA

EPA is the lead agency for the Libby Project, with overall responsibility for implementing the project's response action activities. EPA responsibilities include, but are not limited to, the following:

- Providing overall direction and planning for the project's response action activities
- Providing funding to the Volpe Center for implementing response action activities
- Providing funding for the EPA Emergency Rapid Response Services (ERRS) contractor, or other contractors, for their participation
- Approving plans prepared for implementing response action activities
- Supporting Technical Advisory Group, Community Advisory Group, Operations and Maintenance Group, Environmental Resource Specialist, and onsite EPA manager activities
- Coordinating response activities with the community and local, state, and federal agencies as needed
- Maintaining the IAG with the Volpe Center
- Obtaining access agreements for all activities to be conducted on government and private property

2.2 Volpe Center

EPA has an IAG with the Volpe Center for managing response action activities on the Libby Project. Volpe Center responsibilities include, but are not limited to, the following:

- Providing contractual procurement and management of necessary removal contractor response action activities
- Providing contractual procurement and management of the A&E for planning; design; community involvement, including the EPA Information Center; laboratory analysis; health and safety; technical support; and cleanup oversight efforts
- Procuring and managing other subcontractors as needed, including, but not limited to, those providing common fill, topsoil, landscaping, and security
- Providing environmental engineering and remediation services

- Providing general construction management and support for all project response actions, including, but not limited to, LA asbestos-contaminated soil, insulation, and dust removals; interior and structure demolitions; and subsequent restoration activities
- Providing and managing project disposal efforts, e.g., Lincoln County Asbestos Landfill (Landfill) operations and contract for disposal; mine site repository operations
- Providing administration and closeout of contracts
- Providing site representation for EPA
- Assisting EPA in planning project response activities
- Acquiring project background data and regulatory information as needed
- Reviewing the CSHASP and the removal contractor's site-specific health and safety plan (SSHASP)
- Reviewing design documents provided by the A&E
- Assisting in pre-removal meetings with the resident, A&E, and removal contractor to discuss remediation activities
- Meeting on a daily basis with contractors during the field construction season
- Populating and managing the project database (Libby2), providing quality control checks
- Providing progress tracking of the project
- Supporting community relations during remediation activities, including residential relocations and per diem payments
- Providing administrative record support

2.3 A&E Contractor

Under a contract with the Volpe Center, the A&E will provide architectural and engineering support for response actions on the Libby Project. A&E responsibilities include, but are not limited to, the following:

- Providing investigative and design efforts to identify properties that require project response actions
- Preparing site-specific work plans for properties determined to require project response actions
- Providing the Volpe Center with a schedule of daily project removal and restoration progress
- Assisting the Volpe Center with onsite construction management for site removal and restoration activities

- Providing construction oversight of all removal and restoration activities by the removal contractor(s) to ensure compliance with approved site-specific work plans and project removal criteria
- Providing health and safety (H&S) oversight and technical support for site removal and restoration activities, including the Landfill and the mine site repository
- Documenting inspections and QA/QC (quality control) checks of property removal and restoration activities as necessary
- Collecting investigative and confirmatory samples (e.g., soil, water, air, dust, etc.) as they relate to response actions
- Collecting stationary (perimeter) air samples in accordance with the RAWP SAP (Appendix A) throughout the duration of soil removal activities, and as necessary to evaluate project operations
- Collecting personal task-based air samples in accordance with the RAWP SAP and Air Monitoring Frequency table (Appendix B)
- Evaluating the results of all investigative and confirmatory samples as they relate to project action level criteria
- Evaluating the results of all personal task-based and stationary air samples, recommending engineering controls and personal protective equipment (PPE) requirements as necessary
- Providing sample coordination services to generate chain-of-custody forms and coordinate analysis of samples
- Procuring analytical laboratory services for project samples
- Providing laboratory coordination services to ensure reporting consistency between subcontracted laboratories
- Producing and revising project guidance documents as necessary
- *Procuring surveying services, as needed, for properties requiring soil excavation*
- Providing community involvement coordination (CIC) support (e.g., documenting and discussing all planned remediation activities with property owners; notifying neighboring residents of activities)
- Recording digital photos of properties before, during, and after removal and restoration activities
- Collecting global positioning system (GPS) data for site properties as required by the Volpe Center
- Populating the eLASTIC and Property Closeout Checklist databases, providing quality control checks, and exporting data daily to the Volpe Center

- Maintaining property files that include, but are not limited to, sample data, CIC information, required activity documentation, digital photographs, and EPA correspondence

- Providing copies of all project documentation (e.g., field sample data sheets, inspections, observations, removal checklists, etc.) to the Volpe Center, as requested

- Recommending engineering controls and design standards to the Volpe Center as they relate to project activities

2.4 Removal Contractors

The removal contractors will provide construction services (e.g., contaminated soil, insulation, and dust removals) as they relate to project response activities. Removal contractor responsibilities include, but are not limited to, the following:

- Attending pre-cleanup activity site walks at the properties

- Preparing a SSHASP and addenda, when necessary

- Identifying and acquiring the necessary permits for project activities

- Setting up and maintaining a field office/equipment staging area

- Acquiring utility clearance through Montana U-Dig (800-551-8344) and/or private locate firms

- Ensuring that the site supervisor attends a tailgate meeting to determine that both A&E oversight and the removal contractor have the most current site-specific work plan

- Coordinating with the A&E to document existing site conditions before beginning set-up activities

- Recording digital photos of properties before, during, and after removal and restoration activities

- Preparing interior and exterior work areas for removal actions by constructing necessary containments and decontamination stations

- Removing LA asbestos-contaminated soils, insulation, dust, and other materials in accordance with site-specific work plans and project removal criteria

- Implementing and monitoring engineering controls for construction impact mitigation (i.e., dust control)

- Transporting and disposing of LA asbestos-contaminated soils at the mine site repository or other EPA-approved location in a protective manner in accordance with DOT regulations

- Transporting and disposing of LA asbestos-contaminated insulation, dust, construction debris, and other materials at the Lincoln County Asbestos Landfill or other EPA-approved location in a protective manner in accordance with DOT regulations

- Coordinating with the Volpe Center and A&E for clearance sampling
- Restoring properties in accordance with the RAWP site-specific work plans
- Restoring final grades to provide proper drainage
- Maintaining a site health and safety officer (SHSO) to fulfill the duties as described in this document and the CSHASP
- Documenting regular and frequent site inspections performed by competent person(s) and the SHSO, covering the full-range of site removal and restoration activities, and making this information available to the Volpe Center at the biweekly H&S meetings
- Performing cost tracking as required by the Volpe Center
- Providing adequate pre-work training for its site employees on the requirements contained within the CSHASP, SSHASP, and the RAWP
- Providing supervision and training of subcontractors for adherence to project protocol
- Adhering to requirements in all project contract documents
- Complying with Occupational Safety and Health Administration's (OSHA) general industry requirements

2.5 Other Contractors

Other contractors may be procured by EPA, the Volpe Center, or the A&E to provide fill material, landscaping, laboratory analysis, surveying, security, Landfill operations, government-contracted lodging for residential relocations, and other materials and services. Their responsibilities include, but are not limited to, the following:

- Providing materials or services in accordance with the contract documents and as directed by EPA, the Volpe Center, or the A&E
- Coordinating with EPA, the Volpe Center, or the A&E to provide access for sampling activities, quality assurance inspections, or audits

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Section 3
Design Activities

The A&E is responsible for providing site-specific work plans for the response actions. The following sections briefly describe the design activities, including pre-design inspections, land surveys, and design work that will be conducted. Additional details of these activities are described in other documents, as discussed below.

3.1 Pre-Design Inspections

The A&E will conduct pre-design inspections for the response activities. These inspections expand on an individual property's remedial investigation and help determine what response activities are needed to remove the contaminated soils, insulation, and dust from the property, or to otherwise reduce exposure. Pre-design inspections may include inspecting the interior and exterior of property structures, collecting soil and dust samples, and conducting interviews with tenants and/or owners to confirm information on the location of LA asbestos-contaminated materials. All pre-design inspection activities, including soil sampling, field sketches, building descriptions, etc. will be conducted in accordance with procedures outlined in the PDIWP (CDM 2003b). Dust sampling will be conducted in accordance with the Dust Sampling and Analysis Plan (EPA 2003b).

The property information and analytical data gathered, along with community involvement information, will be used by the A&E to prepare site-specific work plans. These work plans will be used for project planning and subsequent removal contracting purposes.

At this stage, if the pre-design team identifies any structural deficiencies (e.g., inadequate venting, preexisting foundation damage, etc.), they will work with CIC to notify the residents or business owners.

3.2 Land Surveys

A land survey will be conducted for each property with contaminated soils. Land surveys will include topographic information for determining grades during restoration activities, and a property boundary survey to determine the limits of the property for which the removal is being conducted. The surveys will also include all physical and geographic features of the property (e.g., structures/buildings, trees, individual land use areas, etc.). The survey contractor will be a registered and licensed land surveyor in the State of Montana.

3.3 Site-Specific Work Plans

The A&E will prepare a site-specific work plan for each property which will be used for planning, contracting, and remediation purposes. The work plans will be based on this RAWP and the overall site specifications, drawings, and DAR (CDM 2003a). Each site-specific work plan will include a RAWP Addendum and contract drawings for that property. Site-specific work plans will include property specific background information on the inspection activities and sample analytical results. The contract drawings will depict the locations and volumes of LA asbestos-contaminated soil, insulation, and building materials requiring remedial action at the property. The design package will also include the pre-design investigation inspection forms, which are to be used for informational purposes only. All contracting bids will be based on the site-specific work plans.

Unless otherwise noted, there will be voluntary pre-construction site walks at each property to allow the removal contractors to compare site-specific work plans with actual site conditions prior to submitting final bids. The site walk also provides the removal contractors with a forum to ask clarifying questions regarding the site-specific work plan. Site walks may result in changes to the site-specific work plan in the form of an amendment or revision. Site walks will be scheduled by the A&E, and representatives from the Volpe Center, removal contractors, and the A&E will attend.

Section 4
Community Involvement Coordination

The A&E is responsible for providing CIC services for remediation activities. CIC serves as a tenant's and/or property owner's initial point of contact for questions or concerns regarding remediation activities. Property owners and tenants (which can be a residential or a business occupant) are commonly referred to as *residents*.

The following sections describe CIC activities conducted before, during, and after remediation activities.

4.1 Pre-Remediation Activities

4.1.1 Field Review/ Relocation Meeting

CIC, in conjunction with the A&E design team, will review the draft site-specific work plan with the residents. Specific details and necessary changes to the draft site-specific work plan may be incorporated into the final site-specific work plan.

Prior to the meeting, A&E H&S will determine if it's necessary to relocate the resident. At the field review/relocation meeting, CIC explains the remediation process and any necessary relocation information to the tenant and/or property owner. The purpose of the relocation meeting is to discuss what government assistance, such as temporary housing options and reimbursable expenses, will be provided for residents who are relocated during remediation activities.

During the field review/relocation meeting, CIC will:

- Obtain necessary signature(s) from the owner(s) on the *Consent for Entry and Access to Property During Removal Activities* form

If the resident is being relocated, CIC will also:

- Educate residents about temporary relocation options
- Determine resident scheduling conflicts and communicate these to the Volpe Center
- Notify residents of security provided during remediation activities
- Gather necessary information to adequately meet resident needs
- Complete relocation and reimbursement documents and submit to the Volpe Center

4.1.2 Pre-Construction Site Walks

Unless otherwise noted, there will be pre-construction site walks at each property to allow the removal contractors to compare site-specific work plans with actual site conditions before submitting final bids. This may result in changes or revisions to the site-specific work plan, requiring CIC to communicate changes to or from the resident.

4.1.3 Site-Specific Work Plan Signing Meeting

Prior to remediation activities, CIC will conduct the site-specific work plan signing meeting with the residents. The purpose of the signing meeting is to ensure that the residents understand and agree with the remediation activities to be conducted at the property.

Once the site-specific work plan is signed, it is stamped "original" and copies are distributed to the residents. The signed original will be maintained by the A&E in the property file.

4.1.4 Task Order Award

The Volpe Center awards a task order to a removal contractor and subsequently submits the removal contractor's schedule to the A&E. When received by the A&E, CIC contact every impacted resident with the scheduled dates of remediation activities as quickly as possible, in case there are significant scheduling problems.

A&E CIC will also verify relocation information with the resident. If the resident is to be staying at a government-contracted lodging facility, CIC will make the necessary reservations on the residents' behalf (accommodations other than a government-contracted lodging facility are made directly by the resident) after receiving approval from the government.

Before remediation begins, CIC will collect any keys necessary for property access during the site activities. CIC will also review any pertinent reminders, e.g., firearm safety, mail delivery hold, instructions for feeding fish and plants, etc. with the resident. Since residents are not allowed to return to a property once remediation activities have started, they are instructed to contact CIC regarding any issues that arise (e.g., emergency retrieval of items from the property).

4.2 Remediation Activities

4.2.1 Start of Remediation Activities

A tailgate meeting will be held with the removal contractor's site supervisor, A&E oversight, and CIC to review site remediation activities and to ensure that the removal contractor and A&E oversight personnel have consistent and current site-specific work plans. The Volpe Center onsite representative and/or EPA onsite manager may also attend, if available.

CIC and A&E oversight will conduct a site walkthrough and thoroughly document the site's existing conditions, including, but not limited to: existing feature damage; existing structure material damage; operability of utility systems within designated work zones; and all interior and exterior areas.

A&E CIC also notifies nearby properties of remediation activities and provides a contact number for problems or questions.

4.2.2 During Remediation Activities

During the removal, CIC maintains communication with the Volpe Center, the removal contractor, other A&E staff, and the resident. As directed, CIC is responsible for discussing any changes that arise to the site-specific work plan with the resident.

CIC communicates with A&E oversight as needed to track the progress of work at each property. The frequency that CIC updates the resident varies, depending on each resident's individual needs and the circumstances of each property. CIC also communicates with the government-contracted lodging facilities to coordinate changes to reservations accordingly, after receiving approval from the government.

4.2.3 End of Remediation Activities

After remediation activities have been completed, but prior to a restoration final inspection, CIC and A&E oversight will conduct a site walkthrough and thoroughly document the site's conditions - similar to the inspection done when remediation activities began. The purpose is to document existing conditions upon return of property to the residents. It also proactively identifies any outstanding restoration issues which are the removal contractor's responsibility.

4.3 Post-Remediation Activities

4.3.1 Moving Resident Home

CIC works together with the Volpe Center and removal contractor to determine the earliest possible point that the resident can safely move home. The resident will not be allowed to move home until the results of any clearance samples meet the clearance criteria established by EPA and all restoration work which could significantly impact the resident's health and safety is completed. Minor restoration work (e.g., landscaping and small repairs) may need to be completed after the resident moves home.

When directed, CIC authorizes the relocated resident to return home. At this time, CIC returns house keys, completes reimbursement claim forms, assembles and demonstrates the HEPA Vacuum, and if applicable, educates the resident on care of new sod and hydroseed. CIC is also responsible for sending the claim form and all receipts to the Volpe Center.

Once the resident has moved home, CIC coordinates the resolution of any outstanding restoration issues with A&E restoration oversight. CIC is available to respond as needed.

4.3.2 Site-Specific Completion Form

After the remediation activities have been completed, the A&E prepares the site-specific completion form. This form is a summary of the remediation activities performed and any known contamination that may remain on the property. When possible, CIC will conduct a meeting with the resident to review and sign the document. However, when a resident is unresponsive or refuses to sign, the form will be mailed to the resident without signature.

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Section 5
Contaminated Soil Removal

The removal contractor will remove LA asbestos-contaminated soils from residential, commercial, and industrial properties in accordance with the removal and clearance criteria established by the EPA. In general, soils will be removed if LA concentrations of investigation and/or characterization sample results meet or exceed the removal action level criteria as established by the EPA. Additionally, visual inspections may be used to determine areas requiring removal. Details regarding action levels and clearance criteria for soil are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

The removal contractor will furnish all labor, supervision, materials, equipment, tools, permits, and incidentals necessary to perform all contaminated soil removal activities.

If it is determined by A&E H&S that the residents must be temporarily relocated during remediation activities, they will be required to leave their homes and/or property. Upon approval from the Volpe Center, the resident will be provided with temporary housing by the government. The government will be responsible for the cost of any approved relocation and will provide to the resident(s), the government's daily food allotment for the duration of their relocation.

Businesses may be closed during remediation activities. No costs for loss of business will be provided by EPA. However, relocation assistance may be provided upon approval by EPA.

Removal contractors are required to adhere to their submitted removal schedule to minimize the impact of the cleanup on the residents or businesses.

Due to the hazardous nature of the work, access to properties for residents or business owners will not be allowed until the results of the clearance samples meet the clearance criteria established by EPA and all restoration work which could significantly impact the resident's or business owner's health and safety is completed. Only under emergency situations will items be retrieved. Economic and time considerations for the property's residents or businesses will be considered when scheduling work.

EPA will provide HEPA vacuums to owners whose properties have undergone cleanups. The Volpe Center and A&E are responsible for procuring and distributing HEPA vacuums in accordance with the HEPA Vacuum Program Memorandum (Volpe Center 2003).

5.1 Removal Contractor Documentation

Removal contractors are responsible for submitting to the Volpe Center, as part of their SSHASP, a Designation of Competent Person Form (Form L of the CSHASP's Appendix A) which designates a competent person for each work safety category listed.

The removal contractor's SHSO and competent person is each responsible for providing regular and frequent inspections of removal property activities, including site preparation, removal, and restoration activities, to ensure that appropriate precautions are implemented to protect public and worker safety. These inspections are to be documented by both the SHSO and competent person and made available to the Volpe Center at the biweekly H&S meetings, held with the Volpe Center Site Manager, removal contractor SHSO, and A&E H&S.

In addition, the removal contractor is responsible for completing an Activity Hazard Analysis (AHA) form (Form G of the CSHASP's Appendix A) for each removal property. The AHA form will be submitted to A&E H&S for review prior to the start of a site's removal work.

5.2 Subcontractor Activities

The removal contractor is responsible for any project work performed by its subcontractors, including pre-worksite, site preparation, site removal, and site restoration activities. The removal contractor is responsible for ensuring that its subcontractors adhere to all applicable federal, state, and project requirements and guidance documents, including the CSHASP, removal contractor SSHASP, RAWP, and site-specific work plans.

5.3 Pre-Worksite Activities

Prior to arriving at the site, the removal contractor is responsible for:

- Notifying local utility companies or private companies to identify and mark any utility lines within the designated work areas, in accordance with OSHA Standard 29 Code of Federal Regulations (CFR) 1926.651(b)(1).

Prior to beginning any site preparation or excavation, the removal contractor is responsible for:

- Verifying the location of underground utilities or installations, in accordance with OSHA Standard 29 CFR 1926.651(b)(2). The removal contractor assumes full responsibility for damage to existing utility features that were not properly identified. These will include, but are not limited to: sewer/septic lines; drain fields; telephone/cable lines; gas and water lines; electrical connections; and irrigation systems.

Prior to beginning any site preparation activities, the removal contractor and A&E are each responsible for:

- Conducting a site walkthrough and thoroughly documenting the site's existing conditions, including, but not limited to: existing feature damage; existing structure material damage; operability of utility systems within designated work zones; equipment pathways and placement areas; changes in conditions that could result in the presence of LA asbestos after prior investigations were completed; and an inspection of all interior and exterior areas.

Appropriate levels of respiratory protection for project-related activities are provided in Section 7 of the CSHASP. Removal contractors are also required to provide a PPE training program for personnel within their SSHASPs.

5.4 Site Preparation

The removal contractor's site supervisor, A&E oversight, and CIC will hold a tailgate meeting on the first day of site setup to review site remediation activities and to ensure that the removal contractor and A&E oversight personnel have consistent and current site-specific work plans. Additionally, imminent hazards identified will be evaluated with A&E oversight to determine if corrective actions are necessary.

All tools and equipment used by the removal contractor for site preparation, removal, and restoration activities must be approved by A&E H&S prior to their usage onsite.

The removal contractor is responsible for the following:

- Implementing safety precautions, including use of appropriate PPE, if contaminated materials are expected to be disturbed.
- Utilizing appropriate engineering controls to prevent contaminant migration as a result of remediation activities.
- Implementing and maintaining dust control throughout the duration of site activities, from site preparation through restoration, in accordance with Montana Code Annotated (MCA) Title 75 (Environmental Protection), Administrative Rules of Montana (ARM) Title 17, and National Emissions Standards for Hazardous Air Pollutants (NESHAPs) asbestos regulations (40 CFR Part 61).
- Maintaining a copy of contract documents, including the site-specific work plan and SSHASP, at each work site throughout setup, removal, and restoration activities.
- Providing temporary electric power and potable water for the duration of site activities.
- Ensuring electrical safety throughout the duration of site activities as required in Section 4.5.7 of the CSHASP and all applicable OSHA Standards, including 29 CFR 1926.400 Subpart K. All activities performed within 10 feet of energized overhead electrical lines must be evaluated as part of the site AHA by the removal contractor, and appropriate precautions must be implemented before remediation work may begin.
- Ensuring that all appropriate lockout/tagout (LO/TO) procedures, in accordance with project and OSHA requirements, including OSHA Standards 29 CFR 1926.416 and 29 CFR 1926.417, are implemented for any necessary shutdowns of a structure's electrical sources throughout the duration of site activities.
- Ensuring that only licensed electricians perform electrical repair work at a site.
- Ensuring that only licensed electricians perform disconnections and reconnections of underground and overhead electrical power lines.
- Ensuring that only licensed plumbers perform plumbing repair work at a site.
- Ensuring that only licensed personnel perform repair work on gas, propane, or oil lines at a site.

- Identifying and posting residential traffic and pedestrian points of hazard with legible traffic signs, in accordance with OSHA Standard 29 CFR 1926.200(g)(1), throughout the duration of removal and restoration activities.

- Providing site traffic signage in compliance with DOT regulations, including, but not limited to, temporary stop signs when necessary.

- Identifying and evaluating any existing residential mechanical equipment within the work zones, isolating or removing any potential hazards.

- Placing/Staging removal equipment such as, but not limited to, loaders, excavators, decontamination trailers, and water storage tanks, in a manner that minimizes inconvenience and risk to the public.

- Keeping all sidewalks and other public access pathways free of equipment during non-work hours, or providing a sufficiently permanent barrier to prevent pedestrian or vehicle access. Blocked pedestrian or vehicle access pathways will require rerouting by the removal contractor, in accordance with OSHA Standard 29 CFR 1926.200(g)(2).

- Securing sites to prevent children and pets from accessing work areas, during work and non-work hours.

- Demarcating exclusion zone boundaries with orange fencing and yellow caution tape, and posting ingress/egress points with appropriate asbestos and PPE signage, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(i). All removal activities will be conducted within an appropriately designed exclusion zone. The exclusion zone boundaries may only be removed when final clearance criteria is met.

- Demarcating support zone boundaries with orange fencing and yellow caution tape.

- Demarcating waste load out, personnel, and equipment pathways as part of the exclusion zone.

- Protecting all areas of the property where work activities are performed from inclement weather by implementing any reasonable safeguards necessary during removal and restoration activities.

- Ensuring that power is supplied to any refrigerators, freezers, or other items identified in the site-specific work plan or by the A&E.

- Providing fire extinguishers, in accordance with OSHA Standard 29 CFR 1926.150(c)(1)(VI), throughout the site's work areas, including, but not limited to, the exclusion zone and decontamination facility.

- Repairing or replacing in kind all items damaged during remediation activities.

- Ensuring that skid mounted sheds and other movable support structures located in areas identified for excavation are: washed where in contact with contaminated soil, relocated to a non-contaminated area, and returned to their former location after restoration is complete.

- Moving automobiles, trailers, campers, or other similar items, if necessary, prior to cleanup activities, but only after the appropriate owner's permission is granted. These items will be returned to their original location by the removal contractor after restoration activities are complete.
- Adhering to all transportation and disposal requirements stated within the RAWP, including Section 16 of Appendix B's Construction Specifications.
- Developing a handling plan for the collection, storage, transportation, and disposal of liquid waste generated at remediation properties.
- Implementing pollution control measures throughout all site activities.

The removal contractor will be responsible for maintaining these aspects of site preparation, and all appropriate safety precautions, throughout the duration of removal and restoration activities.

5.4.1 Protection of Existing Features

The removal contractor will protect existing utilities, structures, outbuildings, foundations, and improvements (i.e., selected trees, sidewalks, driveways, and other items) during all work phases at the site.

All soil removal work around foundations will be performed so that a 1:1 slope away from the foundation is maintained at all times.

Any onsite propane tanks interfering with soil removal or restoration work will need to be moved. The removal contractor is responsible for contacting the proper utility company, arranging for the move, and ensuring that its placement following excavation is performed by a licensed and qualified fitter in accordance with local utility codes.

5.4.2 Containment Setup

The removal contractor will construct an exclusion zone inside of the designated work area to ensure the health and safety of the workers and public. Exclusion zone boundaries will be demarcated with orange fencing and/or red asbestos tape, based on the size and type of removal activities to be performed, and removal contractor needs. The exclusion zone will encompass the entire contaminated area, including selected noncontaminated areas adjacent to the excavation area. These noncontaminated areas will be utilized as a contamination reduction zone (CRZ) for personnel and heavy equipment ingress/egress, and for staging of waste bags and other necessary equipment. In some circumstances, the exclusion zone may be moved (i.e., sliding exclusion zone) during a cleanup activity to facilitate the cleanup. No adjustment to the exclusion zone will occur without the approval of A&E H&S or oversight personnel.

The removal contractor is responsible for inspecting and maintaining the designated containment areas to ensure they are of sound construction and functioning as designed until final clearance criteria is achieved.

Asbestos warning and PPE requirement signs, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(ii)(b), will be posted at all ingress and egress points of the exclusion zone so that site personnel may read the signs and be aware of necessary protective steps before entering the exclusion zone. The signs will also serve to warn the public of the exclusion zone's dangers.

All contaminated material load out and storage areas are considered extensions of the exclusion zone. They must be fully demarcated and lined with polyethylene sheeting to ensure that clean areas adjacent to the exclusion zone are not cross contaminated. The removal contractor will ensure that each haul truck's windows are up, drivers remain in the cab, and air conditioning units are off when inside the extension of the exclusion zone.

The removal contractor will provide adequate lighting within the work areas, in accordance with OSHA Standard 29 CFR 1926.56(b).

The removal contractor will address any potential fall hazards within the work areas, in accordance with OSHA Standard 29 CFR 1926.501.

The removal contractor is responsible for ensuring that all appropriate asbestos-containing material (ACM) handling procedures are implemented and in accordance with OSHA Standard 29 CFR 1926.1101(l)(2).

Once the exclusion zone has been approved by A&E H&S, all personnel entering the exclusion zone must wear the appropriate Level C PPE for their assigned task. Removal contractors are required to provide a PPE training program for personnel within their SSHASPs. Section 7 of the CSHASP provides a review of task-based project PPE requirements.

5.4.3 Personnel Decontamination

The removal contractor will establish a properly demarcated, HEPA filtered, 3-stage decontamination trailer or equivalent, hereafter referred to as a facility, consisting of an equipment room (dirty room), shower area, and a clean room for personnel decontamination, in accordance with OSHA Standard 29 CFR 1926.1101(g). Personnel decontamination procedures must be posted in the clean and dirty rooms so that personnel may read and take necessary steps to ensure their safety. The removal contractor must perform regular housekeeping duties within all decontamination facility rooms to ensure and maintain their cleanliness. Documentation of such housekeeping will be posted in the clean room of the decontamination facility and made available to A&E H&S upon request.

The removal contractor is responsible for maintaining a 3-stage decontamination facility onsite until clearance results meet removal clearance criteria.

The removal contractor will use potable water for all personnel decontamination, in accordance with OSHA Standard 29 CFR 1910.141(b)(1)(i). All potable water delivery systems must be disinfected on a regular schedule, as directed by A&E H&S, with greater frequency during the summer months. Documentation of potable water equipment inspections and disinfections must be maintained by the removal contractor, made visible to personnel using a particular water source, and provided to A&E H&S upon request. Wastewater generated from personnel decontamination must be disposed of at the Lincoln County Asbestos Landfill or mine site repository, or passed through a

20 and 5 micron filter and disposed of as sanitary waste. The removal contractor shall set up one decontamination facility for each property or group of properties if the properties are contiguous.

Upon approval from A&E H&S, if removal activities are expected to last for less than one-half of a work day (i.e., less than 4 hours), the removal contractor may perform small scale, short duration removals in Modified Level C and without a 3-stage decontamination facility at the site. If permission is granted for Modified Level C PPE, the removal contractor must maintain a suitable means onsite, approved by A&E H&S, for PPE, equipment, and personnel decontamination. This means of decontamination will be maintained onsite by the removal contractor until clearance results meet removal clearance criteria.

Specific requirements regarding the decontamination process for both personnel and equipment are to be presented in the removal contractor's SSHASP.

5.4.4 Equipment Decontamination

The removal contractor is responsible for implementing heavy equipment decontamination procedures when transporting equipment from site to site, and when equipment is removed from the project.

If a full-size decontamination pad is available at the site, heavy equipment will be rinsed off with water to remove all exterior contamination prior to transport. The removal contractor shall ensure that all appropriate controls of decontamination water are implemented to prevent releases of material outside of the exclusion zone.

At most sites, it is not feasible to install a full-size decontamination pad. In these cases, the removal contractor must use the following alternative measures, singly or in combination, to ensure worker safety and public protection during all contaminated equipment transportation. These measures must be taken prior to any final clearance sampling.

- The removal contractor may spray off exterior contamination back into the excavated hole or capture it on polyethylene sheeting, prior to transporting equipment off site.
- The removal contractor may wrap contaminated areas of the heavy equipment with polyethylene sheeting and duct tape to prevent material release during transport.

In addition, removal contractors are responsible for ensuring that all haul truck and haul vehicle exteriors are protected during loading with polyethylene sheeting and decontaminated, as necessary, prior to leaving the exclusion zone, including extensions of the exclusion zone.

All heavy equipment must undergo a full interior and exterior decontamination before being taken off use from the project. Air filters must be removed, replaced, and disposed of at the Lincoln County Asbestos Landfill as ACM. A&E H&S must be notified by the removal contractor before any heavy equipment is removed from project service. A&E H&S will verify the decontamination of the equipment once completed by the removal contractor.

Equipment Pathways

Equipment pathway controls will be implemented. That is, the paths the equipment will traverse during the work will be controlled. These controls are designed to minimize contamination of equipment during soil load-out. These controls will consist of, but are not limited to, covering driving pathways within excavations and covering truck dump boxes with 6-mil thick polyethylene sheeting to prevent cross-contamination during contaminated soil load-out.

Any material used as a haul pathway, such as plywood or plastic sections, will require prior approval from A&E H&S. The removal contractor is responsible for a complete decontamination of any such approved haul pathway material, if reusable, before it leaves the exclusion zone and prior to final clearance sampling. In addition, any reusable haul pathway material used outside of the exclusion zone will be inspected by the removal contractor for contamination prior to its transport offsite. Material observed to be contaminated will be washed off in the site's exclusion zone, if prior to final clearance sampling, or decontaminated or disposed of at the mine site repository or Lincoln County Asbestos Landfill. Material observed to be contaminated will be handled as ACM during transport from the site. If the haul pathway material is observed by the removal contractor's competent person, removal contractor's SHSO, A&E oversight, or A&E H&S to be sufficiently deteriorated so as to prevent proper decontamination, the removal contractor will dispose of it as ACM at the Lincoln County Asbestos Landfill.

Equipment Transport

All transport of heavy equipment by the removal contractor will be performed in accordance with all applicable DOT regulations.

A&E H&S reserves the right to inspect all removal contractor equipment decontamination and transport procedures for adherence to the preceding protocol.

5.4.5 H&S Inspection

The removal contractor's SHSO will be responsible for inspecting all aspects of a site's setup prior to an inspection by A&E H&S. The removal contractor's SHSO will notify A&E H&S when a site's setup is ready for inspection and an AHA form has been completed. A&E H&S will then perform a site containment inspection to ensure compliance with applicable project and OSHA regulations. Removal work may not begin until a site's setup is approved by A&E H&S.

5.4.6 Trees, Shrubs, and Other Debris

Any vegetation (e.g., trees, shrubs) to be removed will be identified in the site-specific work plan, and will be disposed of at an approved site (e.g., mine site repository). Tree and shrub removal will be performed as defined in the site-specific work plan. Chain sawing operations are a recognized safety hazard, and are to be performed in accordance with OSHA Standard 29 CFR 1910.266(e)(2).

Yard debris to be removed will be included in the site-specific work plan, and will be disposed of at an approved site.

The removal contractor will assess all tree cutting and removal as part of the site AHA, which will be submitted to and reviewed by A&E H&S prior to the start of site work. The removal contractor will ensure that all personnel performing tree removal activities are adequately trained and equipped to perform the task in a safe manner.

The removal contractor will be responsible for covering exposed tree roots within a cleared (i.e., soil clearance results meet clearance criteria) excavated area with a minimum of 4 inches of government approved topsoil. Any vermiculite that is still visible around tree roots after excavation will also be covered with a minimum of 4 inches of topsoil. In addition, the covered areas will be watered by the removal contractor on a regular and sufficient basis.

5.4.7 Concrete, Decks, and Other Items

Items located in yards such as concrete, decks, fencing, and other site improvements that require demolition in order to access contaminated soils will be identified in the site-specific work plan. The items to be demolished will be disassembled, cut, uprooted, or otherwise removed using the appropriate equipment and procedures. Any general construction debris not considered to be contaminated will be transported to the Lincoln County Landfill. Contaminated items and construction debris will be handled as ACM and properly disposed of at the Lincoln County Asbestos Landfill or mine site repository. A&E oversight or H&S will decide whether the items and construction debris are to be handled as ACM prior to any demolition work.

The following items will be removed as indicated:

- **Pavement**: Bituminous pavement, asphalt, and/or concrete to be removed will be demolished using a walk behind concrete saw, or cutoff saw (as required), with appropriate dust suppression measures taken. Items that are removed will be considered contaminated and will be properly disposed. The removal contractor will perform all cutting activities in accordance with all applicable project CSHASP, SSHASP, and OHSA requirements, including OSHA Standard 29 CFR 1926.702(i)(1)-(2).

- Piping: If necessary, underground piping that interferes with soil removal, such as sprinklers, storm drains, water lines or sewer/septic lines will be cut with hacksaws or appropriately sized electric- or gasoline-powered saws. Any sewer piping or miscellaneous debris to be removed will be excavated using an appropriate sized hydraulic excavator and disposed of at the Lincoln County Asbestos Landfill or mine site repository.

The removal contractor will be responsible for ensuring that hazardous and non-hazardous materials are handled appropriately and segregated for disposal.

All items not scheduled to be demolished will be protected during the removal phase. Safe work practices will be employed by all personnel to prevent mishaps to remaining structures, other items, or personnel. The removal contractor will review the site-specific work plan for specific safety requirements.

5.4.8 Cleaning of Yard Items

The removal contractor will HEPA vacuum and/or wet wipe as necessary loose items, such as, but not limited to, yard ornaments, bicycles, and outdoor grills, that are in contact with contaminated soil and located within the established exclusion zone. Items will then be moved to another uncontaminated part of the yard or storage area; stored in a Connex-type temporary storage box; given to the home or business owner for safekeeping; or disposed of by the removal contractor in accordance with the site-specific work plan. For stacked items such as lumber and firewood, the layer in contact with the contaminated soil will be cleaned or disposed of by the removal contractor in accordance with the site-specific work plan.

5.4.9 Stumps

Stumps are to be removed as specified in the site-specific work plans. If stump removal is necessary, it will be performed after final clearance is achieved and after the initial 6 inch lift of backfill is placed.

Removal contractors are responsible for ensuring that all applicable safety precautions are taken during stump removal.

5.5 Soil Excavation

5.5.1 Contaminated Soil Removal

The removal contractor will be responsible for selecting the appropriate equipment for conducting the excavation based on the site-specific work plan. The equipment may include an appropriate sized hydraulic excavator, a vacuum truck, hand tools, and dust control equipment, depending on the size and complexity of the removal. All necessary soil within the exclusion zone will be excavated according to site-specific work plan requirements and clearance criteria.

All excavations, embankments, stockpiles, haul roads, permanent and temporary access roads, waste staging and storage areas, stabilization materials handling areas, and other work areas may cause a dust hazard. Adequate dust suppression must be maintained throughout the duration of all removal contractor site activities, including restoration. Visible dust emissions, whether onsite or leaving the site, are strictly prohibited. The removal contractor is solely responsible for complying with the project's dust suppression requirements.

The usage of water, generally via water hoses and water trucks, will be the primary method of dust suppression. Additional methods include, but are not limited to, covering haul pathways with gravel, and working methodically and with care when handling soil.

If there is no water source available, adequate, and ready at the site for dust suppression, the removal contractor is not permitted to perform excavation or soil handling of any kind.

Following the excavation of contaminated soils within the exclusion zone, A&E oversight will inspect the sidewalls and bottom of the excavation. If there is vermiculite in large quantities still visible in the excavation, the removal contractor will be directed to remove an additional 6 inches of contaminated soil until, in the judgment of A&E oversight personnel, the remaining soils are expected to meet soil clearance criteria or the excavation extends to 3 feet below ground surface (bgs), which is the maximum project excavation depth.

When the soil remaining in the excavation area is expected to meet soil clearance criteria, A&E oversight will collect confirmation soil samples in accordance with the RAWP SAP and the following Section 5.5.4. If the sample results indicate that the remaining soils comply with the clearance criteria, the excavation will be considered complete. If the sample results indicate that clearance criteria is not met within the excavation, the removal contractor will be directed to excavate an additional 6 inches bgs until soil clearance criteria is expected to be met or the maximum excavation depth of 3 feet bgs is reached.

This iterative process will continue until the sample results indicate that soil clearance criteria have been met.

If contamination is still visible at 3 feet bgs, the removal contractor will stop excavating and place orange safety fencing in the bottom of the excavation. Contamination deeper than 3 feet bgs will only be excavated under special circumstances and only with approval of EPA.

Excavation depths which differ from those stated in the site-specific work plans will be documented by A&E oversight and communicated to property owners via a Property Closeout Checklist.

Any remaining soil stockpiles at the end of the work day will be covered to prevent dust and contamination migration out of the site's exclusion zone. All such stockpiles must be authorized by A&E H&S or oversight.

Any changes to excavation quantities stated in the site-specific work plans will be discussed with the Volpe Center Site Manager prior to excavation.

5.5.2 Soil Removal from Crawlspaces

All contaminated material removal to be performed in crawlspaces will be evaluated on a site-by-site basis. Details for removal will be included in the site-specific work plans. Soil removal from crawlspaces will be done in accordance with the site-specific work plans, and will require approval of A&E H&S and the Volpe Center onsite representative.

The removal contractor will be responsible for protecting and maintaining the integrity of all foundation and support system features within crawlspaces.

5.5.3 Application of Concrete or Shotcrete

The removal contractor may be required to apply concrete or shotcrete as a means of encapsulating remaining LA asbestos contamination within soils that are difficult to access. Such applications will require prior approval of the Volpe Center and will be indicated in the site-specific work plans. Sections 7 and 17 of Appendix B's Construction Specifications contain additional information pertaining to concrete and shotcrete application.

5.5.4 Confirmation Soil Sampling

Confirmation soil sampling may be performed simultaneously with the excavation of contaminated soils. That is, if the excavation is large enough, confirmation samples may be collected in areas of the excavation that are completed, while the removal contractor completes excavation in other areas. If confirmation sampling is performed simultaneously with the excavating activity and areas of the excavation are deemed complete, the removal contractor is responsible for ensuring that that there is no cross contamination. Confirmation sampling will be conducted in accordance with the RAWP SAP.

A&E oversight is responsible for collection and analysis of confirmation soil sampling.

Clearance criteria may be adjusted as more information becomes available. Details regarding action levels and clearance criteria are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

5.5.5 Transportation and Disposal

Contaminated material will be excavated and live-loaded into trucks or trailers directly at the property, with care taken to prevent contamination of the trucks. Polyethylene sheeting will be placed over the side of the truck or trailer bed to prevent any contaminated material from spilling on the truck. The utmost care will be given during loading to ensure that the truck or trailer exterior remains clean; however, trucks or trailers will be cleaned with water should the decontamination be warranted.

Truck and trailer beds should be sealed watertight. Any damaged or inadequately sealed beds observed by the removal contractor's competent person, removal contractor's SHSO, A&E oversight, or A&E H&S will be immediately removed from service until the necessary repairs or corrections are made.

Trucks cabs will be equipped with positive air pressure HEPA filter systems. The removal contractor will ensure that all operators are fully trained in usage of the air filtration systems.

Controlled pathways will be constructed over uncontaminated property areas so that trucks or trailers can be driven to the area(s) requiring excavation with minimal disruption to the existing vegetation. Controlled pathways and materials will adhere to the requirements set forth in Section 5.4.4.

Prior to departing the property, trucks and trailers will have tarps secured over the beds. Any damaged or inadequate tarps observed by the removal contractor's SHSO, removal contractor's competent person, A&E oversight, or A&E H&S will be immediately removed from service until the necessary repairs or corrections are made.

Contaminated soils will be disposed of at the mine site repository.

The removal contractor will ensure that all haul trucks used to transport contaminated material undergo annual DOT certification inspections. Copies of the inspection reports will be submitted to A&E H&S prior to the truck's usage on the project.

5.5.6 Control of Surface Water

Responsibility for the care of surface water will be borne by the removal contractor until completion of restoration work. The removal contractor will provide the materials, equipment, and personnel needed to control surface water and to protect the cleanup work from damage by water. Using temporary control measures, the removal contractor will be responsible for preventing surface water from running into and out of the exclusion zones.

If necessary, portable pumps will be used to remove any ponded water. Any water removed from an excavation will be treated as contaminated fluids and disposed of at the mine site repository or Lincoln County Asbestos Landfill.

5.5.7 Pollution Prevention

Material will not be allowed to enter and pollute any surface water or groundwater in the project area. Vehicles and equipment will be lubricated or fueled in a controlled manner. All removal contractor personnel and subcontractors will comply with applicable federal, state, and local laws concerning pollution of surface and groundwater. Special measures, with approval from EPA, may be implemented to prevent chemicals, fuels, oils, greases, and other materials from entering public waters.

5.6 Air Sampling During Contaminated Soil Removal

5.6.1 Stationary Air Sampling

During contaminated soil removal, the perimeter of the exclusion zone will be monitored for asbestos structure migration by collecting a stationary air sample from the downwind direction at the exclusion zone boundary. All stationary sampling will be conducted in accordance with the RAWP SAP.

The A&E is responsible for collection and analysis of stationary sampling.

If more than 2 LA structures are detected on a perimeter air sample, site-specific engineering controls and work practices will be reviewed by the Volpe Center Site Manager, A&E H&S, removal contractor SHSO, and removal contractor competent person. The removal contractor is responsible for implementing any necessary corrective actions in a timely manner.

5.6.2 Personal Breathing Zone Air Sampling

Task-based personal breathing zone (BZ) air samples will be collected by the A&E on removal contractor personnel conducting contaminated soil removal to document that the level of respiratory protection is adequate for the task being conducted. All personal BZ sampling will be conducted in accordance with the RAWP SAP. Sampling frequencies for personal BZ air monitoring were established using task-based personal BZ sampling data collected during the 2002 - 2006 Libby Project field seasons. Project task-based sampling frequencies are included in Appendix B. Personal BZ air sampling will consist of collecting one time weighted average (TWA) sample and one short-term exposure limit (STEL) (i.e., one 30-minute excursion) sample per task a minimum of every 6 months.

If personal BZ samples are reported above the respective TWA or STEL for the appropriate sample, the sample will be confirmed by transmission electron microscopy (TEM) as specified in the RAWP SAP. If the result is confirmed by TEM, the Volpe Center, A&E H&S, and removal contractor will assess work practices, evaluate contributing factors, and modify engineering controls as necessary.

BZ sample results will be supplied to the removal contractor in order to satisfy OSHA requirements. The removal contractor is responsible for posting these results in a location readily available to its employees.

5.7 Security

For removal properties requiring relocation of the residents, the government will supply a qualified security contractor to provide security whenever the removal contractor is not onsite. The removal contractor will coordinate with the A&E to ensure that proper security is being provided during the time the resident is relocated from their property. The level of security may vary from periodic patrols to onsite full-time based on the location of the property and whether it is adjacent or close to other properties being remediated. This will be evaluated and determined by the Volpe Center.

The removal contractor is responsible for site security during regular working hours (when the government provided security contractor is not onsite).

Section 6
Vermiculite-Containing Insulation Removal

The removal contractor shall remove VCI from residential, commercial, and industrial properties in accordance with the removal and clearance criteria established by the EPA. VCI will either be removed or left in place at a property based on the EPA removal criteria. If the insulation may be accessed and disturbed under normal conditions, such as in attics, it will generally be removed. If the insulation is well contained and will not be disturbed under normal conditions, such as in walls, it will generally be left in place. If left in place, any openings through which the insulation may enter the living space, such as electrical outlets or light fixtures, will be sealed off to prevent exposure. Details regarding action levels and clearance criteria are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

The removal contractor will furnish all labor, supervision, materials, equipment, tools, permits, and incidentals necessary to perform all VCI removal activities.

If a resident or business owner represents to the EPA that they will remodel a portion or all of a structure immediately following a removal, and have specific plans in place to do so, EPA may decide to remove VCI from certain areas of the structure to be remodeled. VCI will only be removed from those areas impacted by the remodeling and no restoration will be performed (e.g., walls will be removed down to the studs, cleaned, cleared, and reinsulated, and the owner will then complete the remodeling, including the replacement of the wall sheathing material).

If it is determined by A&E H&S that the residents must be temporarily relocated during remediation activities, they will be required to leave their homes and/or property. Upon approval from the Volpe Center, the resident will be provided with temporary housing by the government. The government will be responsible for the cost of any approved relocation and will provide to the resident(s), the government's daily food allotment for the duration of their relocation.

Businesses may be closed during remediation activities. No costs for loss of business will be provided by EPA. However, relocation assistance may be provided upon approval by EPA.

Removal contractors are required to adhere to their submitted removal schedule to minimize the impact of the cleanup on the residents or businesses.

Due to the hazardous nature of the work, access to properties for residents or business owners will not be allowed until the results of the clearance samples meet the clearance criteria established by EPA and all restoration work which could significantly impact the resident's or business owner's health and safety is completed. Only under emergency situations will items be retrieved. Economic and time considerations for the property's residents or businesses will be considered when scheduling work.

EPA will provide HEPA vacuums to owners whose properties have undergone cleanups. The Volpe Center and A&E are responsible for procuring and distributing HEPA vacuums in accordance with the HEPA Vacuum Program Memorandum (Volpe Center 2003).

6.1 Removal Contractor Documentation

Removal contractors are responsible for submitting to the Volpe Center, as part of their SSHASP, a Designation of Competent Person Form (Form L of the CSHASP's Appendix A) which designates a competent person for each work safety category listed.

The removal contractor's SHSO and competent person is each responsible for providing regular and frequent inspections of removal property activities, including site preparation, removal, and restoration activities, to ensure that appropriate precautions are implemented to protect public and worker safety. These inspections are to be documented by both the SHSO and competent person and made available to the Volpe Center at the biweekly H&S meetings, held with the Volpe Center Site Manager, removal contractor SHSO, and A&E H&S.

In addition, the removal contractor is responsible for completing an AHA form (Form G of the CSHASP's Appendix A) for each removal property. The AHA form will be submitted to A&E H&S for review prior to the start of a site's removal work.

6.2 Subcontractor Activities

The removal contractor is responsible for any project work performed by its subcontractors, including pre-worksite, site preparation, site removal, and site restoration activities. The removal contractor is responsible for ensuring that its subcontractors adhere to all applicable federal, state, and project requirements and guidance documents, including the CSHASP, removal contractor SSHASP, RAWP and site-specific work plans.

6.3 Pre-Worksite Activities

Prior to beginning any site preparation activities, the removal contractor and A&E are each responsible for:

- Conducting a site walkthrough and thoroughly documenting the site's existing conditions, including, but not limited to: existing feature damage; existing structure material damage; operability of utility systems within designated work zones; equipment pathways and placement areas; changes in conditions that could result in the presence of LA asbestos after prior investigations were completed; and an inspection of all interior and exterior areas.

Appropriate levels of respiratory protection for project-related activities are provided in Section 7 of the CSHASP. Removal contractors are also required to provide a PPE training program for personnel within their SSHASPs.

6.4 Site Preparation

The removal contractor's site supervisor, A&E oversight, and CIC will hold a tailgate meeting on the first day of site setup to review site remediation activities and to ensure that the removal contractor and A&E oversight personnel have consistent and current site-specific work plans. Additionally, imminent hazards identified will be evaluated with A&E oversight to determine if corrective actions are necessary.

All tools and equipment used by the removal contractor for site preparation, removal, and restoration activities must be approved prior by A&E H&S prior to their usage onsite.

The removal contractor is responsible for the following:

- Implementing safety precautions, including use of appropriate PPE, if contaminated materials are expected to be disturbed.
- Utilizing appropriate engineering controls to prevent contaminant migration as a result of remediation activities.
- Implementing and maintaining dust control throughout the duration of site activities, from site preparation through restoration, in accordance with MCA Title 75 (Environmental Protection), ARM Title 17, and NESHAPs asbestos regulations (40 CFR Part 61).
- Maintaining a copy of contract documents, including the site-specific work plan and SSHASP, at each work site throughout setup, removal, and restoration activities.
- Ensuring that all attic accesses are of adequate size (i.e., a minimum of 18 inches by 18 inches) for personnel and equipment ingress/egress.
- Providing temporary electric power and potable water for the duration of site activities.
- Ensuring that all appropriate LO/TO procedures, in accordance with project and OSHA requirements, including OSHA Standards 29 CFR 1926.416 and 29 CFR 1926.417, are implemented for a structure's electrical sources throughout the duration of site activities.
- Ensuring electrical safety throughout the duration of site activities as required in Section 4.5.7 of the CSHASP and all applicable OSHA Standards, including 29 CFR 1926 Subpart K. All activities performed within 10 feet of energized overhead electrical lines must be evaluated as part of the site AHA by the removal contractor, and appropriate precautions must be implemented before remediation work may begin.
- Ensuring that only licensed electricians perform electrical repair work at a site.
- Ensuring that only licensed electricians perform disconnections and reconnections of underground and overhead electrical power lines.
- Ensuring that only licensed plumbers perform plumbing repair work at a site.
- Ensuring that only licensed personnel perform repair work on gas, propane, or oil lines at a site.
- Identifying and posting residential traffic and pedestrian points of hazard with legible traffic signs, in accordance with OSHA Standard 29 CFR 1926.200(g)(1), throughout the duration of removal and restoration activities.
- Providing site signage in compliance with DOT regulations, including temporary stop signs when necessary.

- Identifying and evaluating any existing residential mechanical equipment within the work zones, isolating or removing any potential hazards.

- Placing/Staging removal equipment such as, but not limited to, vacuum machines, vacuum boxes, decontamination trailers, and water storage tanks, in a manner that minimizes inconvenience and risk to the public.

- Keeping all sidewalks and other public access pathways free of equipment during non-work hours, or providing a sufficiently permanent barrier to prevent pedestrian or vehicle access. Blocked pedestrian or vehicle access pathways will require rerouting by the removal contractor in accordance with OSHA Standard 29 CFR 1926.200(g)(2).

- Securing sites to prevent children and pets from accessing work areas, during work and non-work hours.

- Demarcating exclusion zone boundaries and posting ingress/egress points with appropriate asbestos and PPE signage, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(i). All removal activities will be conducted within an appropriately designed exclusion zone. The exclusion zone boundaries may only be removed when final clearance criteria is met.

- Demarcating support zone boundaries with orange fencing and yellow caution tape.

- Demarcating waste load out, personnel, and equipment pathways as part of the exclusion zone.

- Protecting all areas of the property where work activities are performed from inclement weather by implementing any reasonable safeguards necessary during removal and restoration activities.

- Ensuring that power is supplied to any refrigerators, freezers, or other items identified in the site-specific work plan or by the A&E.

- Providing fire extinguishers, in accordance with OSHA Standard 29 CFR 1926.150(c)(1)(VI), throughout the site's work areas, including, but not limited to, the exclusion zone and decontamination facility.

- Utilizing all necessary precautions to ensure the structural integrity of the building is maintained during remediation activities.

- Repairing or replacing in kind all items damaged during remediation activities.

- Moving automobiles, trailers, campers, or other similar items, if necessary, prior to cleanup activities, but only after the appropriate owner's permission is granted. These items will be returned to their original location by the removal contractor after restoration activities are complete.

- Protecting site utility piping from freezing conditions and sensitive property features against weather elements. If freezing temperatures are expected, negative air machines may be turned off during non-work hours once bulk removal is complete, with prior approval of A&E H&S.

- Adhering to all transportation and disposal requirements stated within the RAWP, including Section 16 of Appendix B's Construction Specifications.
- Developing a handling plan for the collection, storage, transportation, and disposal of liquid waste generated at remediation properties.
- Implementing pollution control measures throughout all site activities.

The removal contractor will be responsible for maintaining these aspects of site preparation, and all appropriate safety precautions, throughout the duration of removal and restoration activities.

6.4.1 Protection of Existing Features

The removal contractor will be responsible for protecting existing features and systems of the property that are to be left in place. The heating, ventilating, and air conditioning (HVAC) system should be rendered inoperable, sealed, and isolated to protect it from contamination during removal contractor activities, in accordance with OSHA Standard 29 CFR 1926.1101(g)(4)(III). All appropriate LO/TO procedures are to be implemented for HVAC systems prior to the start of site work and throughout the duration of remediation activities.

The removal contractor will protect electrical wiring located in the site's work areas throughout the duration of remediation activities.

6.4.2 Containment Setup

The removal contractor will construct an exclusion zone inside of the designated work area to ensure the health and safety of the workers and public. No adjustment to the exclusion zone will occur without the approval of A&E H&S or oversight personnel.

The removal contractor is responsible for inspecting the designated containment areas to ensure that any penetrations which VCI or other contaminated materials may escape or leak into as a result of remediation activities are identified and sealed.

The removal contractor will design a negative pressure enclosure (NPE) encompassing the exclusion zone to isolate the removal activities and prevent unwanted structure migration. The NPE will be constructed according to OSHA requirements, including OSHA Standard 29 CFR 1926.1101(g)(5). All critical barriers, such as, but not limited to, exposed vents, grilles, and windows inside of the work area, must be HEPA vacuumed prior to being sealed. All activities within the designated NPE will be performed in Level C, with appropriate respiratory protection and PPE as defined in Section 7 of the CSHASP.

The removal contractor will place the NPE under negative pressure by installing HEPA equipped negative air filtration units. HEPA air filtration units are to achieve a minimum of 4 air exchanges per hour, in accordance with OSHA Standard 29 CFR 1926.1101(g)(5)(i)(A)(2), and are to be placed in a manner which pulls contamination away from the worker's breathing zone. HEPA air filtration units will be exhausted to outside air rather than back into another part of the building.

Asbestos warning and PPE requirement signs, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(ii)(B), will be posted at all ingress and egress points of the exclusion zone so that site personnel may read the signs and be aware of necessary protective steps before entering the exclusion zone.

The removal contractor shall install Z-flaps at ingress and egress points using 2 layers of 6-mil fire retardant polyethylene sheeting to allow passage into the NPE while minimizing migration of contaminants to the outside. Tyvek suit change out stations, or other means approved by A&E H&S, will be required to prevent cross contamination if accessing the designated containment area through a clean living space or loading out ACM waste.

The removal contractor will provide adequate lighting within the work areas, in accordance with OSHA Standard 29 CFR 1926.56(b).

The removal contractor will address any potential fall hazards within the work areas, in accordance with OSHA Standard 29 CFR 1926.501.

The removal contractor must build containments of sufficient size to allow for proper work safety practices (e.g., use of Tyvek change out stations), extending the containment beyond the contaminated area if necessary. All containment extensions require prior approval by A&E H&S.

The removal contractor is responsible for inspecting and maintaining the designated containment areas to ensure they are of sound construction and functioning as designed until final clearance criteria is met.

The removal contractor is responsible for ensuring that all appropriate ACM handling procedures are implemented and in accordance with OSHA Standard 29 CFR 1926.1101(l)(2).

Once the exclusion zone has been approved by A&E H&S, all personnel entering the exclusion zone must wear the appropriate Level C PPE for their assigned task. Removal contractors are required to provide a PPE training program for personnel within their SSHASPs. Section 7 of the CSHASP provides a review of task-based project PPE requirements.

6.4.3 Personnel Decontamination

The removal contractor will establish a properly demarcated, HEPA filtered, 3-stage decontamination trailer or equivalent, hereafter referred to as a facility, consisting of an equipment room (dirty room), shower area, and a clean room for personnel decontamination, in accordance with OSHA Standard 29 CFR 1926.1101(g). Personnel decontamination procedures must be posted in the clean and dirty rooms so that personnel may read and take necessary steps to ensure their safety. The removal contractor must perform regular housekeeping duties within all decontamination facility rooms to ensure and maintain their cleanliness. Documentation of such housekeeping will be posted in the clean room of the decontamination facility and made available to A&E H&S upon request.

The removal contractor is responsible for maintaining these 3-stage decontamination facilities onsite until clearance results meet removal clearance criteria.

The removal contractor will use potable water for all personnel decontamination, in accordance with OSHA Standard 29 CFR 1910.141(b)(1)(i). All potable water delivery systems must be disinfected on a regular schedule, as directed by A&E H&S, with greater frequency during the summer months. Documentation of potable water equipment inspections and disinfections must be maintained by the removal contractor, made visible to personnel using a particular water source, and provided to A&E H&S upon request. Wastewater generated from personnel decontamination must be disposed of at the Lincoln County Asbestos Landfill or mine site repository, or passed through a 20 and 5 micron filter and disposed of as sanitary waste. The removal contractor shall set up one decontamination facility for each property or group of properties if the properties are contiguous.

Upon approval from A&E H&S, if removal activities are expected to last for less than one-half of a work day (i.e., less than 4 hours), the removal contractor may perform small scale, short duration removals in Modified Level C PPE and without a 3-stage decontamination facility at the site. If permission is granted for Modified Level C PPE, the removal contractor must maintain a suitable means onsite, approved by A&E H&S, for PPE, equipment, and personnel decontamination. This means of decontamination will be maintained onsite by the removal contractor until clearance results meet removal clearance criteria.

Specific requirements regarding the decontamination process for both personnel and equipment are to be presented in the removal contractor's SSHASP.

6.4.4 Equipment Decontamination

The removal contractor will be responsible for decontaminating or disposing of any equipment or materials used for removal activities within the exclusion zone. Items undergoing decontamination will be wet wiped and/or HEPA vacuumed prior to leaving the exclusion zone. Items to be disposed of will be bagged and handled as ACM prior to leaving the exclusion zone.

6.4.5 H&S Inspection

The removal contractor's SHSO will be responsible for inspecting all aspects of a site's setup prior to an inspection by A&E H&S. The removal contractor's SHSO will notify A&E H&S when a site's setup is ready for inspection and an AHA form has been completed. A&E H&S will then perform a site containment inspection to ensure compliance with applicable project and OSHA regulations. Removal work may not begin until a site's setup is approved by A&E H&S.

6.4.6 Moving/Cleaning of Household Items

The removal contractor shall HEPA vacuum and/or wet wipe all items within the designated containment areas. All items, such as clothing, that are in contact with VCI, will be cleaned or disposed of by the removal contractor as stated in the site-specific work plans. If items are moved from the removal area and stored in a Connex-type box, an inventory will be prepared by the removal contractor. All moving of household items requires prior approval by A&E oversight.

6.5 VCI Removal from Attics

6.5.1 Building Material Demolition

Any demolition required to access and remove VCI will be stated in the site-specific work plans. Demolition activities not stated in site-specific work plans will require prior approval by the Volpe Center. Demolition may consist of cutting, sawing, or other intrusive activities used to access VCI for removal. The removal contractor may not begin any demolition work until it is approved by A&E H&S. The removal contractor will inform A&E oversight personnel prior to commencing and upon completing demolition activities each work day.

The removal contractor's competent person will evaluate demolition work to ensure that the required engineering controls and work practices necessary to perform the job in a safe manner have been properly implemented.

All interior demolition activities must be performed with point-of-cut ventilated (POCV) power tools. All tools and equipment used by the removal contractor to perform demolition activities must be approved by A&E H&S. Additional engineering controls to minimize particulate levels, such as construction of mini enclosures to isolate demolition activities, use of automatic misters, and use of HEPA equipped local exhaust ventilation, may be instituted upon approval from A&E H&S.

6.5.2 Bulk Removal

The removal contractor will perform bulk removal of VCI in attics, as identified in the site-specific work plan, using a HEPA equipped vacuum apparatus. All bulk removal activities will be conducted with proper engineering controls and work practices to ensure personnel safety and removal success. Adequate dust suppression must be maintained throughout the duration of bulk removal activities. Dust suppression may be achieved by using adequate amounts of potable water through automatic misters, airless sprayers, or Hudson sprayers. Amended water may also be used if necessary. Water usage will be carefully controlled by the removal contractor to ensure that property damage does not occur.

The removal contractor will utilize proper work practices such as good housekeeping, strategic cleaning from clean to dirty, and proper planning to create a safe and productive work environment during bulk removal activities. The removal contractor will also employ administrative controls, such as limiting the number of personnel and the amount of unnecessary vacuum hose in the NPE, to minimize particulate levels.

As established by EPA removal criteria, the removal contractor will remove other insulation, such as, but not limited to, fiberglass or cellulose, if it is in contact or shares airspace with existing VCI. Insulation may only be removed in accordance with site-specific work plans, or by approval from the Volpe Center.

Once the removal contractor's competent person determines that bulk removal is complete, work will proceed to detail cleaning. The removal contractor's competent person is responsible for ensuring that appropriate respiratory protection and engineering controls are maintained when transitioning between bulk removal and detail cleaning.

6.5.3 Detail Cleaning

The purpose of the detail cleaning is to remove any remaining insulation from cracks and crevices.

Once the removal contractor's site supervisor determines detailing activities are complete, they will request an inspection from A&E H&S personnel. A&E H&S will inspect the removal areas to ensure that all cleaning activities have been performed according to site-specific work plan requirements and project removal criteria.

6.5.4 Blocking

Blocking activities are to be performed only with prior approval from A&E H&S.

If there is insulation in a particular area that is determined by A&E H&S to be unreachable, the removal contractor may construct a suitable permanent barrier or blocking, as directed and approved by A&E H&S, to prevent future access. Blocking is to be installed in a manner such that moisture does not build up in insulated areas.

Blocking material in non-living areas may consist of 1" Styrofoam Brand closed cell polystyrene insulation as manufactured by Dow Chemical Company, plywood, or an equivalent approved by the Volpe Center. The type of blocking material used in each removal scenario will require prior approval of A&E H&S, and will be determined at the A&E H&S inspection following detail cleaning.

Blocking materials in living space areas will consist of replacement-in-kind materials, and will be specified in site-specific work plans.

Existing ventilation pathways will not be completely blocked without prior approval by the Volpe Center.

A&E oversight will verify and document that the appropriate blocking was performed by the removal contractor.

6.5.5 Encapsulation

The removal contractor may apply colorless encapsulant in non-living space removal areas when detail cleaning is completed. Encapsulation activities are to be performed only with prior approval from A&E H&S.

The removal contractor will use encapsulant which has been approved for project usage by the Volpe Center. The encapsulant will be applied aggressively to all accessible removal area surfaces by using an airless sprayer in conjunction with a 1-horesepower (hp) leaf blower to ensure proper dispersal. The purpose of the encapsulant is to "lock down" any remaining asbestos structures and prevent them from becoming airborne should they be disturbed at a later date. The removal contractor will ensure that sufficient encapsulant is used to adequately lock down any remaining asbestos structures.

The removal contractor is responsible for using sufficient care during application of encapsulant to prevent any damage to direct and indirect areas of the structure. The removal contractor is responsible for repair or replacement of any materials or items damaged as a result of its application.

6.6 VCI Removal from Areas to be Remodeled

As determined by EPA, VCI may be removed from certain contained areas, such as, but not limited to, walls, floors, and ceilings, when the property owner intends to remodel their home or business immediately following the removal or where building materials are in extremely poor condition.

The removal contractor will adhere to the procedures outlined previously in Sections 6.5.1 through 6.5.5 of this RAWP when removing VCI from areas to be remodeled.

6.7 VCI Removal from Crawlspaces

All contaminated material removal to be performed in crawlspaces will be evaluated separately, done in accordance with site-specific work plans, and will require approval of A&E H&S.

The removal contractor will be responsible for protecting and maintaining the integrity of all foundation and support system features within crawlspaces.

6.8 Structure Demolition

All structure demolitions will be evaluated separately, done in accordance with site-specific work plans, and will require approval of the Volpe Center. Demolition specifications are presented in Appendix B, Construction Specifications, Section 13.

6.9 Sealing of Penetrations

In structures undergoing remediation activities, the removal contractor must inspect all living space areas to determine if VCI has leaked into outlets, switches, light fixtures, ceiling fans, electrical boxes, vents, and any other penetrations. If any VCI was observed, the penetration(s) must be cleaned and sealed with flame retardant, project-approved foam sealant or caulk which provides a colorless or clear finish. The results of the inspection must be provided to A&E oversight personnel.

All penetration covers are to be removed by the removal contractor and will remain off until A&E oversight or H&S has inspected the areas.

6.10 Personal Breathing Zone Air Sampling

Task-based personal BZ air samples will be collected by the A&E on removal contractor personnel conducting VCI removal to document that the level of respiratory protection is adequate for the task being conducted. All personal BZ sampling will be conducted in accordance with the RAWP SAP. Sampling frequencies for personal BZ air monitoring were established using task-based personal BZ sampling data collected during the 2002 - 2006 Libby Project field seasons. Project task-based sampling frequencies are included in Appendix B. Personal BZ air sampling will consist of collecting one TWA sample and one STEL (i.e., one 30-minute excursion) sample per task a minimum of every 6 months.

If personal BZ samples are reported above the respective TWA or STEL for the appropriate sample, then the sample will be confirmed by TEM as specified in the RAWP SAP.

BZ sample results will be supplied to the removal contractor in order to satisfy OSHA requirements. The removal contractor is responsible for posting these results in a location readily available to its employees.

6.11 Final Clearance Air Samples

If the designated containment area requires encapsulation, final clearance air samples will be collected by the A&E after the encapsulant has been applied and allowed to dry, and after all blocking activities are complete. Each containment area will have its own clearance sampling event. Final air clearance sampling will be conducted in accordance with the RAWP SAP.

Once the clearance criteria have been met, the removal contractor may remove the containment, and restoration of the removal area can begin.

Clearance criteria may be adjusted as more information becomes available. Details regarding action levels and clearance criteria are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

6.12 Security

For removal properties requiring relocation of the residents, the government will supply a qualified security contractor to provide security whenever the removal contractor is not onsite. The removal contractor will coordinate with the A&E to ensure that proper security is being provided during the time the resident is relocated from their property. The level of security may vary from periodic patrols to onsite full-time based on the location of the property and whether it is adjacent or close to other properties being remediated. This will be evaluated and determined by the Volpe Center.

The removal contractor is responsible for site security during regular working hours (when the government provided security contractor is not onsite).

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Section 7 Contaminated Dust Removal (Interior Cleaning)

The removal contractor will perform LA asbestos-contaminated dust removals from residential, commercial, and industrial properties in accordance with removal and clearance criteria established by EPA. Details regarding action levels and clearance criteria for contaminated dust removal are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

The removal contractor will furnish all labor, supervision, materials, equipment, tools, permits, and incidentals necessary to perform all interior cleaning activities.

If it is determined by A&E H&S that the residents must be temporarily relocated during remediation activities, they will be required to leave their homes and/or property. Upon approval from the Volpe Center, the resident will be provided with temporary housing by the government. The government will be responsible for the cost of any approved relocation and will provide to the resident(s), the government's daily food allotment for the duration of their relocation.

Businesses may be closed during remediation activities. No costs for loss of business will be provided by EPA. However, relocation assistance may be provided upon approval by EPA.

Removal contractors are required to adhere to their submitted removal schedule to minimize the impact of the cleanup on the residents or businesses.

Due to the hazardous nature of the work, access to properties for residents or business owners will not be allowed until the results of the clearance samples meet the clearance criteria established by EPA and all restoration work which could significantly impact the resident's or business owner's health and safety is completed. Only under emergency situations will items be retrieved. Economic and time considerations for the property's residents or businesses will be considered when scheduling work.

EPA will provide HEPA vacuums to owners whose properties have undergone cleanups. The Volpe Center and A&E are responsible for procuring and distributing HEPA vacuums in accordance with the HEPA Vacuum Program Memorandum (Volpe Center 2003).

7.1 Removal Contractor Documentation

Removal contractors are responsible for submitting to the Volpe Center, as part of their SSHASP, a Designation of Competent Person Form (Form L of the CSHASP's Appendix A) which designates a competent person for each work safety category listed.

The removal contractor's SHSO and competent person is each responsible for providing regular and frequent inspections of removal property activities, including site preparation, removal, and restoration activities, to ensure that appropriate precautions are implemented to protect public and worker safety. These inspections are to be documented by both the SHSO and competent person and made available to the Volpe

Center at the biweekly H&S meetings, held with the Volpe Center Site Manager, removal contractor SHSO, and A&E H&S.

In addition, the removal contractor is responsible for completing an AHA form (Form G of the CSHASP's Appendix A) for each removal property. The AHA form will be submitted to A&E H&S for review prior to the start of a site's removal work.

7.2 Subcontractor Activities

The removal contractor is responsible for any project work performed by its subcontractors, including pre-worksite, site preparation, site removal, and site restoration activities. The removal contractor is responsible for ensuring that its subcontractors adhere to all applicable federal, state, and project requirements and guidance documents, including the CSHASP, removal contractor SSHASP, RAWP and site-specific work plans.

7.3 Pre-Worksite Activities

Prior to beginning any site preparation activities, the removal contractor and A&E are each responsible for:

- Conducting a site walkthrough and thoroughly documenting the site's existing conditions, including, but not limited to: existing feature damage; existing structure material damage; operability of utility systems within designated work zones; equipment pathways and placement areas; changes in conditions that could result in the presence of LA asbestos after prior investigations were completed; and an inspection of all interior and exterior areas.

Appropriate levels of respiratory protection for project-related activities are provided in Section 7 of the CSHASP. Removal contractors are also required to provide a PPE training program for personnel within their SSHASPs.

7.4 Site Preparation

The removal contractor's site supervisor, A&E oversight, and CIC will hold a tailgate meeting on the first day of site setup to review site remediation activities and to ensure that the removal contractor and A&E oversight personnel have consistent and current site-specific work plans. Additionally, imminent hazards identified will be evaluated with A&E oversight to determine if corrective actions are necessary.

All tools and equipment used by the removal contractor for site preparation, removal, and restoration activities must be approved by A&E H&S prior to their usage onsite.

The removal contractor is responsible for the following:

- Implementing safety precautions, including use of appropriate PPE, if contaminated materials are expected to be disturbed.

- Utilizing appropriate engineering controls to prevent contaminant migration as a result of remediation activities.

- Implementing and maintaining dust control throughout the duration of site activities, from site preparation through restoration, in accordance with MCA Title 75 (Environmental Protection), ARM Title 17, and NESHAPs asbestos regulations (40 CFR Part 61).

- Maintaining a copy of contract documents, including the site-specific work plan and SSHASP, at each work site throughout setup, removal, and restoration activities.

- Providing temporary electric power and potable water for the duration of site activities.

- Ensuring that all appropriate LO/TO procedures, in accordance with project and OSHA requirements, including OSHA Standards 29 CFR 1926.416 and 29 CFR 1926.417, are implemented for a structure's electrical sources throughout the duration of removal and restoration activities.

- Ensuring electrical safety throughout all phases of site activities as required in Section 4.5.7 of the CSHASP and all applicable OSHA Standards, including 29 CFR 1926 Subpart K. All activities performed within 10 feet of energized overhead electrical lines must be evaluated as part of the site AHA by the removal contractor, and appropriate precautions must be implemented before remediation work may begin.

- Ensuring that only licensed electricians perform electrical repair work at a site.

- Ensuring that only licensed electricians perform disconnections and reconnections of underground and overhead electrical power lines.

- Ensuring that only licensed plumbers perform plumbing repair work at a site.

- Ensuring that only licensed personnel perform repair work on gas, propane, or oil lines at a site.

- Identifying and posting residential traffic and pedestrian points of hazard with legible traffic signs, in accordance with OSHA Standard 29 CFR 1926.200(g)(1), throughout the duration of removal and restoration activities.

- Providing site signage in compliance with DOT regulations, including temporary stop signs when necessary.

- Identifying and evaluating any existing residential mechanical equipment within the work zones, isolating or removing any potential hazards.

- Placing/Staging removal equipment such as, but not limited to, vacuum machines, vacuum boxes, decontamination trailers, and water storage tanks, in a manner that minimizes inconvenience and risk to the public.

- Keeping all sidewalks and other public access pathways free of equipment during non-work hours, or providing a sufficiently permanent barrier to prevent pedestrian or vehicle access. Blocked pedestrian or vehicle access pathways will require rerouting by the removal contractor in accordance with OSHA Standard 29 CFR 1926.200(g)(2).

- Securing sites to prevent children and pets from accessing work areas, during work and non-work hours.

- Demarcating exclusion zone boundaries and posting ingress/egress points with appropriate asbestos and PPE signage, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(i). All removal activities will be conducted within an appropriately designed exclusion zone. The exclusion zone boundaries may only be removed when final clearance criteria is met.

- Demarcating support zone boundaries with orange fencing and yellow caution tape.

- Demarcating waste load out, personnel, and equipment pathways as part of the exclusion zone.

- Protecting all areas of the property where work activities are performed from inclement weather by implementing any reasonable safeguards necessary during removal and restoration activities.

- Ensuring that power is supplied to any refrigerators, freezers, or other items identified in the site-specific work plan or by the A&E.

- Providing fire extinguishers, in accordance with OSHA Standard 29 CFR 1926.150(c)(1)(VI), throughout the site's work areas, including, but not limited to, the exclusion zone and decontamination facility.

- Utilizing all necessary precautions to ensure the structural integrity of the building is maintained during remediation activities.

- Repairing or replacing in kind all items damaged during remediation activities.

- Moving automobiles, trailers, campers, or other similar items, if necessary, prior to cleanup activities, but only after the appropriate owner's permission is granted. These items will be returned to their original location by the removal contractor after restoration activities are complete.

- Protecting site utility piping from freezing conditions and sensitive property features against weather elements. If freezing temperatures are expected, negative air machines may be turned off during non-work hours once bulk removal is complete, with prior approval of A&E H&S.

- Adhering to all transportation and disposal requirements stated within the RAWP, including Section 16 of Appendix B's Construction Specifications.

- Developing a handling plan for the collection, storage, transportation, and disposal of liquid waste generated at remediation properties.

- Implementing pollution control measures throughout all site activities.

The removal contractor will be responsible for maintaining these aspects of site preparation, and all appropriate safety precautions, throughout the duration of removal and restoration activities.

7.4.1 Protection of Existing Features

The removal contractor will be responsible for protecting existing features and systems of the property that are to be left in place. The HVAC system should be rendered inoperable, sealed, and isolated to protect it from contamination during removal contractor activities, in accordance with OSHA Standard 29 CFR 1926.1101(g)(4)(III). All appropriate LO/TO procedures are to be implemented for HVAC systems prior to the start of site work and throughout the duration of remediation activities.

The removal contractor will protect electrical wiring located in the site's work areas throughout the duration of remediation activities.

7.4.2 Containment Setup

The removal contractor will construct an exclusion zone inside of the designated work area to ensure the health and safety of the workers and public. No adjustment to the exclusion zone will occur without the approval of A&E H&S or oversight personnel.

The removal contractor is responsible for inspecting the designated containment areas to ensure that any penetrations which contaminated dust or other materials may escape or leak into as a result of remediation activities are identified and sealed.

The removal contractor shall design an NPE encompassing the exclusion zone to isolate the removal activities and prevent unwanted structure migration. The NPE will be constructed according to OSHA requirements, including OSHA Standard 29 CFR 1926.1101(g)(5). All critical barriers, such as, but not limited to, exposed vents, grilles, and windows inside of the work area, must be HEPA vacuumed prior to being sealed. All activities within the designated NPE will be performed in Level C, with appropriate respiratory protection and PPE as defined in Section 7 of the CSHASP.

The removal contractor will place the NPE under negative pressure by installing HEPA equipped negative air filtration units. HEPA air filtration units are to achieve a minimum of 4 air exchanges per hour, in accordance with OSHA Standard 29 CFR 1926.1101(g)(5)(i)(A)(2), and are to be placed in a manner which pulls contamination away from the worker's breathing zone. HEPA air filtration units will be exhausted to outside air rather than back into another part of the building.

Asbestos warning and PPE requirement signs, in accordance with OSHA Standard 29 CFR 1926.1101(k)(7)(ii)(B), will be posted at all ingress and egress points of the exclusion zone so that site personnel may read the signs and be aware of necessary protective steps before entering the exclusion zone.

The removal contractor will install Z-flaps at ingress and egress points using 2 layers of 6-mil fire retardant polyethylene sheeting to allow passage into the NPE while minimizing migration of contaminants to the outside. Tyvek suit change out stations, or other means approved by A&E H&S, will be required to prevent cross contamination if accessing the designated containment area through a clean living space.

The removal contractor will provide adequate lighting within the work areas, in accordance with OSHA Standard 29 CFR 1926.56(b).

The removal contractor will address any potential fall hazards within the work areas, in accordance with OSHA Standard 29 CFR 1926.501.

The removal contractor must build containments of sufficient size to allow for proper work safety practices (e.g., use of Tyvek change out stations), extending the containment beyond the contaminated area if necessary. All containment extensions require prior approval by A&E H&S.

The removal contractor is responsible for inspecting and maintaining the designated containment areas to ensure they are of sound construction and functioning as designed until final clearance criteria is met.

The removal contractor is responsible for ensuring that all appropriate ACM material handling procedures are implemented and in accordance with OSHA Standard 29 CFR 1926.1101(l)(2).

Once the exclusion zone has been approved by A&E H&S, all personnel entering the exclusion zone must wear the appropriate Level C PPE for their assigned task. Removal contractors are required to provide a PPE training program for personnel within their SSHASPs. Section 7 of the CSHASP provides a review of task-based project PPE requirements.

7.4.3 Personnel Decontamination

The removal contractor will establish a properly demarcated, HEPA filtered, 3-stage decontamination trailer or equivalent, hereafter referred to as a facility, consisting of an equipment room (dirty room), shower area, and a clean room for personnel decontamination, in accordance with OSHA Standard 29 CFR 1926.1101(g). Personnel decontamination procedures must be posted in the clean and dirty rooms so that personnel may read and take necessary steps to ensure their safety. The removal contractor must perform regular housekeeping duties within all decontamination facility rooms to ensure and maintain their cleanliness. Documentation of such housekeeping will be posted in the clean room of the decontamination facility and made available to A&E H&S upon request.

The removal contractor is responsible for maintaining these 3- stage decontamination facilities onsite until clearance results meet removal clearance criteria.

The removal contractor will use potable water for all personnel decontamination, in accordance with OSHA Standard 29 CFR 1910.141(b)(1)(i). All potable water delivery systems must be disinfected on a regular schedule, as directed by A&E H&S, with greater frequency during the summer months. Documentation of potable water equipment inspections and disinfections must be maintained by the removal contractor, made visible to personnel using a particular water source, and provided to A&E H&S upon request. Wastewater generated from personnel decontamination must be disposed of at the Lincoln County Asbestos Landfill or mine site repository, or passed though a 20 and 5 micron filter to be disposed of as sanitary waste. The removal contractor will set up one decontamination facility for each property or group of properties if the properties are contiguous.

Upon approval from A&E H&S, if removal activities are expected to last for less than one-half of a work day (i.e., less than 4 hours), the removal contractor may perform small scale, short duration removals in Modified Level C and without a 3-stage decontamination facility at the site. If permission is granted for Modified Level C PPE, the removal contractor must maintain a suitable means onsite, approved by A&E H&S, for PPE, equipment, and personnel decontamination. This means of decontamination will be maintained onsite by the removal contractor until clearance results meet removal clearance criteria.

Specific requirements regarding the decontamination process for both personnel and equipment are to be presented in the removal contractor's SSHASP.

7.4.4 Equipment Decontamination

The removal contractor will be responsible for decontaminating or disposing of any equipment or materials used for removal activities within the exclusion zone. Items undergoing decontamination will be wet wiped and/or HEPA vacuumed prior to leaving the exclusion zone. Items to be disposed of will be bagged and handled as ACM prior to leaving the exclusion zone.

7.4.5 H&S Inspection

The removal contractor's SHSO will be responsible for inspecting all aspects of a site's setup prior to an inspection by A&E H&S. The removal contractor's SHSO will notify A&E H&S when a site's setup is ready for inspection and an AHA form has been completed. A&E H&S will then perform a site containment inspection to ensure compliance with applicable project and OSHA regulations. Removal work may not begin until a site's setup is approved by A&E H&S.

7.4.6 Moving/Cleaning of Household Items

The removal contractor will HEPA vacuum and/or wet wipe all items within the designated containment areas. All items that are in contact with VCI, will be cleaned or disposed of by the removal contractor as stated in the site-specific work plans. If items are moved from the removal area and stored in a Connex-type box, an inventory will be prepared by the removal contractor. All moving of household items requires prior approval by A&E oversight.

7.5 Cleaning Procedures

The removal contractor will HEPA vacuum and/or wet wipe all horizontal and vertical surfaces to remove contaminated dust from the interior of the structure. Areas such as, but not limited to, closets, chest-of-drawers, and cabinets, will not be opened for cleaning purposes during the interior cleaning process unless identified in the site-specific work plan. Clothes will remain in place and will not be cleaned or disposed of, unless in contact with VCI. All upholstery items (e.g., drapes, bedspreads, couches, and carpets) will be thoroughly cleaned with a HEPA vacuum.

Once the removal contractor's site supervisor determines interior cleaning activities are complete, they will request an inspection from A&E H&S. The inspection will ensure that all interior cleaning activities have been performed according to site-specific work plan requirements and project removal criteria.

7.5.1 Cleaning in Crawlspaces

All contaminated material removal to be performed in crawlspaces will be evaluated separately, done in accordance with site-specific work plans, and will require approval of A&E H&S.

The removal contractor will be responsible for protecting and maintaining the integrity of all foundation and support system features within crawlspaces.

7.5.2 Small Scale Vermiculite Removals

Small Scale Vermiculite Removals will be evaluated and conducted in accordance with the Small Scale Vermiculite Removals Memorandum in Appendix B.

7.5.3 Sealing of Penetrations

In structures undergoing remediation activities, the removal contractor must inspect all living space areas to determine if VCI has leaked into outlets, switches, light fixtures, ceiling fans, electrical boxes, vents, and any other penetrations. If any VCI was observed, the penetration(s) must be cleaned and sealed with flame retardant, project-approved foam sealant or caulk which provides a colorless or clear finish. The results of the inspection must be provided to A&E oversight personnel.

All penetration covers are to be removed by the removal contractor and will remain off until A&E oversight or H&S has inspected the areas.

7.6 Personal Breathing Zone Air Sampling

Task-based BZ air samples will be collected by the A&E on removal contractor personnel conducting contaminated dust removal to document that the level of respiratory protection is adequate for the task being conducted. All personal BZ sampling will be conducted in accordance with the RAWP SAP. Sampling frequencies for personal BZ air monitoring were established using task-based personal BZ sampling data collected during the 2002 - 2006 Libby Project field seasons. Project task-based sampling frequencies are included in Appendix B. Personal BZ air sampling will consist of collecting one TWA sample and one STEL (i.e., one 30-minute excursion) sample per task a minimum of every 6 months.

If personal BZ samples are reported above the respective TWA or STEL for the appropriate sample, then the sample will be confirmed by TEM as specified in the RAWP SAP.

BZ sample results will be supplied to the removal contractor in order to satisfy OSHA requirements. The removal contractor is responsible for posting these results in a location readily available to its employees.

7.7 Final Clearance Air Sampling

Each containment area will have its own clearance sampling event. Final air clearance sampling will be conducted in accordance with the RAWP SAP.

Once the clearance criteria have been met, the removal contractor may remove the containment, and restoration of the removal area can begin.

Clearance criteria may be adjusted as more information becomes available. Details regarding action levels and clearance criteria are found in the EPA Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Site (EPA 2003a).

7.8 Security

For removal properties requiring relocation of the residents, the government will supply a qualified security contractor to provide security whenever the removal contractor is not onsite. The removal contractor will coordinate with the A&E to ensure that proper security is being provided during the time the resident is relocated from their property. The level of security may vary from periodic patrols to onsite full-time based on the location of the property and whether it is adjacent or close to other properties being remediated. This will be evaluated and determined by the Volpe Center.

The removal contractor is responsible for site security during regular working hours (when the government provided security contractor is not onsite).

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Section 8
Restoration

Following the completion of removal activities, a property will be restored to a condition equal to that which existed prior to the removal work.

The removal contractor will decontaminate and demobilize the equipment used for the removal of contaminated soil, VCI, or contaminated dust before restoration. Property restoration will be conducted in Level D PPE and will adhere to the requirements outlined in the CSHASP. Removal contractors are also required to provide a PPE training program for personnel within their SSHASPs.

The removal contractor will furnish all labor, supervision, materials, equipment, tools, permits, and incidentals necessary to perform all exterior and interior restoration activities, except as noted in this Section.

The removal contractor is responsible for submitting product samples, product data, and descriptions of the materials proposed for use in restoration prior to removal activities. All materials require approval by the Volpe Center and property owner prior to their usage. In addition, all materials used in restoration will be new and comply with local building codes.

Dust control will be maintained by the removal contractor at all times. No visible dust emissions are permitted during restoration activities, including transportation of materials to and from sites.

The removal contractor will provide all water necessary to control dust on the property and roadways adjacent to the property, all water necessary for thorough compaction of backfill materials, and all other water necessary to complete restoration activities.

Restoration will comply with Construction Specifications (Appendix B) and the site-specific work plans. During restoration, A&E oversight personnel will perform inspections to ensure this compliance. Appropriate documentation will accompany these inspections.

8.1 Exterior Restoration

Once excavation activities are complete and all necessary clearance samples are collected and meet project-specific clearance criteria, the removal contractor will initiate property restoration.

8.1.1 Fill Material

Specific backfill material to be used for restoration is included in the site-specific work plans.

Fill material may consist of, but is not limited to, the following:

- Common fill
- Structural fill (¾-inch minus)
- Gravel (e.g., ¾-inch washed gravel, pea gravel)
- Topsoil
- Sand
- Potting soil

Unless otherwise noted, topsoil and common fill will be provided by Volpe Center-contracted suppliers. The removal contractor will coordinate with the onsite Volpe Center representative to place orders and schedule delivery. All orders for topsoil and/or common fill must be placed by the removal contractor at least 3 business days before delivery. All other fill material (e.g., structural fill, sand, gravel, potting soil) must be supplied and hauled to the site by the removal contractor. All fill material supplied by the removal contractor must be inspected, sampled (e.g., asbestos, organic/inorganic suite), and approved by the government before its project use. The removal contractor should allow a minimum of 3 weeks for inspection, sample collection, sample analysis, and approval.

8.1.1.1 Common Fill

Common fill will consist of mineral soil substantially free from organic materials, loam, wood, trash and other objectionable materials which may be compressible or which cannot be properly compacted. Common fill will not contain stones larger than 3 inches in any dimension. Common fill will have a liquid limit less than 35 drops and a plasticity index less than 10, and will meet the following gradation percentages:

Sieve Size	Percent Finer by Weight
3 inches	100
#4	50 - 90
#40	15 - 85
#200	0 - 40

8.1.1.2 Topsoil

The topsoil material will be free of foreign matter and objects larger than 1 inch in any dimension, and will meet the following criteria:

Parameter	Value
Texture	loam, sandy loam, or sandy clay loam
Organic Matter	3 to 10 percent
pH	6.0 to 8.0
Electrical Conductivity (EC)	<4 micromhos(mmhos)/centimeter
Sodium Absorption Ratio (SAR)	<12 milliequivalents(meq)/liter
Cation Exchange Capacity	10 - 25 meq/100 gram

The Volpe Center will specify organic content amendment requirements based on the quality control testing results from the government's topsoil procurement program.

8.1.1.3 Other Fill Material

Other fill material may be required as part of the reconstruction and restoration effort. The site-specific work plan will include details on what other fill materials are necessary. All fill material, with the exception of common fill and topsoil, will be provided and hauled by the removal contractor.

Sand will meet the following gradation percentages:

Sieve Size	Percent Finer by Weight
#10	100
#18	90
#200	0

All gravel types and sizes will be specified in the site-specific work plans. Washed gravel will contain no fines.

Structural fill will conform to the requirements listed in Sections 6, 7, and 14 of the Construction Specifications in Appendix B, depending on its purpose.

Removal contractors will use locally available potting soil when necessary.

8.1.2 Placement, Grading, and Compaction

The removal contractor must notify A&E oversight of planned backfilling activities, in order to coordinate A&E evaluations of grading and compaction.

Before backfilling, the excavation area will be examined for any conditions detrimental to restoration. If any unfavorable conditions (e.g., saturated areas, snow, ice) exist, backfilling will not begin until conditions change.

Backfilling and grading will be performed in a manner and sequence that will avoid damage to properties, houses, garages, utility poles, fences, decks, sprinkler systems, streets, or other features adjacent to the work areas. All fill material will be placed using "clean-to-dirty" techniques. That is, fill material will be end-dumped from a clean area and spread to make a path for subsequent loads ensuring the haul trucks do not drive over any contaminated areas.

The removal contractor is responsible for ensuring that:

- All placed and compacted common fill subgrade material, topsoil, and other fill material (e.g., structural fill and gravel) is sloped away from building foundations, regardless of original grade, to allow for proper water drainage. The top of grade will exhibit a minimum slope of 2% within 10 feet, away from foundations.

- All original site grades not interfering with proper drainage (i.e., away from building foundations) are maintained, as indicated on the site-specific work plans.

- Original site drainage conditions are not altered in any way which negatively impacts or damages site materials or buildings.

Compaction equipment will be of suitable type and adequate to obtain the soil densities specified herein, and will provide satisfactory breakdown of materials to form a dense fill. Acceptable compaction equipment includes pneumatic tire, tamping foot, sheepsfoot roller, or vibratory plate compactor. The use of other compaction equipment by the removal contractor requires prior approval by the Volpe Center.

The removal contractor will be solely responsible for modifications to the moisture content of all materials required to achieve the specified compactions herein.

The removal contractor will be responsible for the quality of work and materials during earthwork operations and for any settlement of backfill materials. All work found unsatisfactory shall be corrected by the removal contractor in an approved manner and at no additional cost to the government.

8.1.2.1 Common Fill

Common fill will be used to backfill the excavated area to within 6 inches below final grade in yard areas and to within 18 inches below final grade in gardens or flowerbeds, as indicated in the site-specific work plan. Modifications to this criterion may be directed by EPA.

The common fill material will be placed and compacted with a moisture content that produces a relatively uniform finish, free from irregular surface changes. Common fill shall be placed in layers (lifts) that result in compacted soil not exceeding 6 inches in thickness. The fill lifts will be compacted to at least 90 percent of the maximum dry density, within 3 percent of optimum moisture, as determined by laboratory test American Society for Testing Materials (ASTM) D698 (standard Proctor). The A&E will be performing periodic compaction tests to ensure placed material meets the required compaction.

8.1.2.2 Topsoil

Topsoil will be used to backfill the top 6 inches of the excavation in yard areas and the top 18 inches of the excavation in gardens and flowerbeds as indicated on the site-specific work plan. Modifications to this criterion may be directed by EPA.

The removal contractor will not place topsoil over frozen subgrade, snow, ice, saturated soil, or ponded water.

The topsoil will be placed so that haul trucks do not repeatedly drive over newly placed topsoil. In yard areas, the topsoil shall be lightly compacted during placement with a tracked-Bobcat, hand roller, or equivalent. The topsoil lifts will be compacted to at least 85 percent of the maximum dry density as determined by laboratory test ASTM D698 (standard Proctor). Topsoil shall be placed within 3 percent of optimum moisture. In gardens and flowerbeds, the topsoil will be placed and compacted with hand-tools. To account for settling, topsoil will be mounded 4 inches above borders in gardens, flowerbeds and planters. Immediately after placement, the surface will be hand-raked to remove stiff clods, lumps, roots, other foreign material, and objects larger than 1 inch in any dimension. All depressions caused by settlement will be filled with additional topsoil, compacted, and regraded to match existing contours.

In locations to receive sod, the removal contractor is required to coordinate the finish grade of the rolled topsoil with the government's landscaping contractor. Typically sod settles approximately 1 to 1½ inches depending on subgrade preparation. The removal contractor will place, grade and compact topsoil so that when the sod is initially placed, it is 1 to 1½ inches above an abutting lawn, sidewalk, or driveway surface elevation to allow for the anticipated settlement. Fine, hand grading, in areas within 1 foot of the abutting lawn, sidewalk or driveway to receive sod, will be the responsibility of the government's landscaping contractor. Once the sod has settled, it must blend into abutting lawn areas, sidewalks and driveways so that there are no tripping hazards.

8.1.3 Fences, Decks, and Other Exterior Items

Any fences, decks, or other items temporarily removed during site preparation will be reassembled or replaced in kind by the removal contractor, as stated in the site-specific work plan. These items will be reassembled or replaced before installing landscaping. Any damages incurred during disassembly shall be repaired by the removal contractor. Upon completion, these structures will be inspected by the government representative for quality of work and durability. If sheds or other structures were removed during site preparation, they will be returned to their original locations as specified in the site-specific work plan.

8.1.4 Landscaping

All landscaping will be performed by the government landscaping contractor. In the event that vegetation (e.g., trees, grass) is damaged by the removal contractor during removal activities, the removal contractor will repair or replace damaged items.

Weather permitting, the landscape contractor will landscape the property within 5 business days from the removal final inspection (Section 8.3.2).

8.2 Interior Restoration

Once VCI removal, interior cleaning, and/or interior demolition activities are complete and all necessary clearance samples are collected and meet project-specific clearance criteria, the removal contractor will begin interior restoration.

8.2.1 Attic Accesses

The removal contractor may be required to enlarge interior and/or exterior accesses, or to create new accesses to facilitate removal activities. If done, the accesses will be restored to a condition equal to that which existed prior to initiating the removal work, as indicated on the site-specific work plan.

8.2.2 Insulation

Insulation removed from the attic, basement, or crawlspace will be replaced with either blown-in or batt insulation to meet the thermal resistance value (R-value) requirements established by State of Montana residential and building codes. Insulation types and R-values will be specified in the site-specific work plans. Insulation will be installed in accordance with Section 12 of the Construction Specifications, included in Appendix B. Installed insulation will not touch the rafters and will allow proper ventilation throughout the attic. Baffles and other accessories will be installed to allow continuous ventilation from the soffit to the roof ridge, even if soffit vents do not exist.

If the property owner is in the process of remodeling, a credit for replacement insulation materials only may be provided to the property owner. The site-specific work plan will detail the insulation credit type and area.

8.2.3 Interior

All moved household items will be returned to their original place (unless otherwise specified). Any holes in the walls and/or ceilings created to remove insulation or accidentally made during cleanup operations will be repaired and returned to their pre-cleanup condition, referring to the previously documented conditions and contents of the interior of the home. If carpeting is damaged, it will be professionally cleaned or may require disposal and replacement as directed by EPA.

The removal contractor will test all electrical circuits for continuity and operation to confirm that no damage was caused to electrical wiring and system components during removal work.

8.3 Government Inspection

Throughout the restoration effort, the government representative will provide restoration oversight to ensure restoration efforts are being performed in accordance with this document and the site-specific work plan.

Once the removal contractor and A&E oversight have agreed that all restoration activities are complete, the following inspections will be performed:

- Post-cleanup inspection
- Removal final inspection

8.3.1 Post-Cleanup Inspection

The post-cleanup inspection (post-inspection) walkthrough will be performed by the government representative and CIC. Unless prior arrangements are made, post-inspections shall be scheduled before 3:00 p.m. to allow adequate time for an address of punch list items by the removal contractor and a removal final inspection (Section 8.3.2) before returning the property back to the resident.

During the post-inspection, the government representative and CIC will review the site-specific work plan to ensure all items are completed, with the exception of landscaping. The walkthrough will include a thorough documentation of the property's existing conditions so that, if necessary, post-cleanup conditions can be compared to pre-removal conditions.

Damages observed during the post-inspection and not identified during the site walkthrough at startup will be included on the punch list of items to complete before the removal final inspection. Documentation such as photographs, field notes, and pre-cleanup checklists will be referenced to determine if damages are pre-existing or a result of the removal activities. If it is determined damages result from removal activities, the removal contractor will furnish all labor, equipment, and materials to repair damages to their pre-existing condition.

8.3.2 Removal Final Inspection

Unless significant punch list items remain, the removal final inspection will be scheduled approximately one hour after the post-inspection. The removal final inspection will be attended by the government representative, removal contractor's site supervisor, and CIC. The EPA field team leader may also attend the removal final inspection meeting. The purpose of the removal final inspection is to review post-cleanup site conditions and ensure that all work was conducted in accordance with the RAWP and site-specific work plan, punch list items are completed, and the property is presentable for the resident.

When the government representative decides that the property is ready, CIC will coordinate with the resident to schedule a move in time (if applicable). CIC will then complete the activities listed in Sections 4.3.1 and 4.3.2.

Section 9
Schedule

The removal contractor will submit a schedule for remediation work with each task order.

Schedule requests are generally obtained from the resident during the field review/ relocation meeting. Information is gathered about vacation plans, family events, and any other upcoming activities that might interfere with the scheduling of remediation activities for their property. The A&E incorporates scheduling requests in the design submittals to the Volpe Center, for consideration in the final Request for Proposal (RFP).

The A&E and removal contractor will keep any delays in work activities as short as possible. All delays will be communicated immediately to the Volpe Center.

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Section 10
References

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Appendix A

Final Draft RAWP SAP

Final Draft
Response Action Sampling and Analysis Plan
for
Libby Asbestos Site
Libby, Montana

November 2003

Contract No. DTRS57-99-D-00017
Task Order No. C0025

Final Draft
Response Action Sampling and Analysis Plan
for
Libby Asbestos Site
Libby, Montana

November 2003

Contract No. DTRS57-99-D-00017
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Contents

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Acronyms

°F	degrees Fahrenheit
AHERA	Asbestos Hazard Emergency Response Act
bgs	below ground surface
BZ	breathing zone
CAR	corrective action request
COC	chain-of-custody
DQA	data quality assessment
DQO	data quality objectives
EDD	electronic data deliverables
EZ	Exclusion Zone
f/mm^2	fibers per square millimeter
FSDS	field sample data sheets
FSP	field sampling plan
GPS	global positioning system
Grace	W.R. Grace Company
HASP	health and safety plan
IDL	instrument detection limit
LA	tremolite, actinolite, richterite, and winchite
NA	not applicable
ND	non-detect
NFG	National Functional Guidelines
NPE	negative pressure enclosure
NVLAP	National Voluntary Laboratory Accreditation Program
OU	Operable Unit
OU3	Operable Unit 3
OU4	Operable Unit 4
PCME	PCM Equivalent
PE	performance evaluation
PLM	polarized light microscopy
PM	project manager
PPE	personal protective equipment

QA	quality assurance
QC	Quality Control
QMP	Quality Management Plan
RA	Removal Action
RAWP	response action work plan
RPM	remedial project manager
SAP	sampling and analysis plan
SOP	standard operating procedure
TWA	Time Weighted Average
VCI	vermiculite containing insulation
Zonolite	Universal Zonolite Insulation Company

Section 1
Introduction

This document serves as the response action sampling and analysis plan (SAP) for the cleanup efforts as part of the draft response action work plan (RAWP) for the Libby Asbestos Site Operable Unit (OU) 4 under the Volpe Center Contract. This SAP outlines the sampling and analysis to be conducted during cleanup of contaminated soil, vermiculite containing insulation (VCI), and interior cleaning at the site.

This section provides a general explanation of the purpose of the SAP for the RAWP and organization of this document. An expanded site background is provided in Section 2.

The cleanup activities being completed at the Libby Asbestos Site include the removal of VCI, contaminated soil, and contaminated dust from residential, commercial, and industrial properties. The VCI encountered in the structures is typically found in attics where residents placed it for insulating the structure. It is sometimes encountered in exterior walls for the same reason, and sometimes in interior and exterior walls because it fell through openings at the top of the walls from the attic. The contaminated soil encountered at the property is generally due to vermiculite placed there for a variety of reasons, including amending of soil in flowerbeds and gardens, leveling of low spots, and backfilling of utilities. It also may have been spread in yards from other sources. Contaminated dust encountered in the structures is due to a variety of reasons, including VCI leaking into the living spaces from the attic or walls and vermiculite tracked in from the outdoor source locations discussed above. The approach to the actual cleanup of these media is found in the text of the RAWP located in the main body of this document.

During cleanup of the properties, sampling and analysis is conducted to ensure the source material is removed to the cleanup criteria and ensure the health and safety of the workers at the site and the public in the vicinity of the site. This includes sampling and analysis following removal of VCI and contaminated dust for clearance of the areas being cleaned; following removal of contaminated soils to confirm that the contamination is removed from the excavation area; and during the removal of VCI and contaminated soil to ensure safety of the workers and the public is maintained throughout the cleanup.

This SAP outlines the field sampling plan as it pertains to sampling completed during and after soil excavation, VCI removal, and interior cleaning. The purpose of this SAP is to describe the sampling objectives, locations, measurement methods, and the quality assurance (QA) requirements for sampling of the soil and air during cleanup efforts. The SAP is organized as follows:

Section 1 - Introduction
Section 2 - Site Background

Part I: Field Sampling Plan
Section 3 - Sampling Strategy, Locations, and Rationale
Section 4 - Field Activity Methods and Procedures

Part II: Quality Assurance Project Plan
Section 5 - Project Management
Section 6 - Measurement and Data Acquisition
Section 7 - Assessment and Oversight
Section 8 - Data Validation and Usability
Section 9 - References
Appendix A - Standard Operating Procedures
Appendix B - Air Sample Collection Procedures
Appendix C - Analytical Methods
Appendix D - Request for Modification Forms

1.1 Objectives

This section defines objectives of the soil and air confirmation, air monitoring, and the intended use of the data. The primary objective of these efforts is to determine the presence of LA during and after soil excavation and VCI removal at the properties identified in the Contaminant Screening Study (CSS) and remedial investigation (RI).

The specific objectives are to:

- Sampling during removal - confirmation soil sampling to ensure remaining media meets cleanup standards listed in the RAWP

- Sampling during removal - stationary air sampling to ensure that excavation is not spreading asbestos into air

- Sampling after removal - stationary air and confirmation soil sampling to ensure what remains meets cleanup standards as defined by EPA and listed in the draft RAWP document

- Sampling throughout VCI removal/excavation - breathing zone air sampling, a health and safety measure, to ensure workers are not being exposed to asbestos

- Sampling will be ongoing for the duration o the cleanup activities at the site, which are anticipated to last until 2007

1.2 Project Schedule and Deliverables

The results of the SAP will be placed in the property cleanup files at the office in Libby and maintained by CDM/Volpe/EPA. Other project deliverables and schedules are discussed in the RAWP for this work (The main body of this document).

Section 2
Site Background

This section describes the site location and the history.

2.1 Site Location

The Libby asbestos site is located within Sections 3 and 10, T30N, R31W of the Libby Quadrangle in Lincoln County, Montana (Figure 1-1 in the RAWP). The site includes homes and other businesses, which may have become contaminated with asbestos fibers as a result of the vermiculite mining and processing conducted in and around the City of Libby (Figure 1-2 in the RAWP).

2.2 Site History

Vermiculite was discovered 7 miles northeast of Libby, Montana in 1881 by gold miners. In the early 1920s, Mr. Edward Alley began initial mining operations on the vermiculite ore body located approximately 7 miles northeast of Libby. Full-scale operations began later that decade under the name of the Universal Zonolite Insulation Company (Zonolite). This ore body contains a solid solution series of amphibole asbestos fibers with compositions including tremolite, actinolite, richterite, and winchite (herein referred to as LA) as defined by B.E. Leake et al. (1997). Unlike the commercially exploited chrysotile asbestos, LA material has never been used commercially on a wide scale, and, for the mine's operating life, it was considered a byproduct of little or no value. The commercially exploited vermiculite was used in a variety of products, including insulation and construction materials, as a carrier for fertilizer and other agricultural chemicals, and as a soil conditioner.

The vermiculite ore was mined using standard strip mining techniques and conventional mining equipment. The ore was then processed in an onsite dry mill to remove waste rock and overburden material. Once processed, the ore was transported from the mine to the former screening plant, which sorted the ore into five size ranges. After the sorting process, the material was shipped to various locations across the United States, for either direct inclusion in products or for "expansion" prior to use in products. Expansion (also known as "exfoliation" or "popping") was accomplished by heating the ore, usually in a dry kiln, to approximately 2,000 degrees Fahrenheit (°F). This process explosively vaporizes the water contained within the phyllosilicate structure causing the vermiculite to expand by a factor of 10 to 15. This produces the vermiculite material most commonly sold as soil conditioner for gardens and greenhouses.

In Libby, operations handling this material occurred at four main locations: the mine and mill located on Rainy Creek Road on top of Zonolite Mountain; the former screening plant and railroad loading station located at the intersection of Highway 37 and Rainy Creek Road and directly across the Kootenai River, respectively; the former expansion/export plant (the former export plant) located immediately west of Highway 37 where it crosses the Kootenai River; and at the former expansion plant located at the end of Lincoln Road, near 5th Street (Figure 2-3). The Lincoln Road Expansion Plant went off line sometime in the early 1950s. Inspections are underway to determine the exact location of this facility.

In 1963, the W.R. Grace Company (Grace) purchased Zonolite and continued vermiculite-mining operations in a similar fashion. In 1975, a wet milling process was added that operated in tandem with the dry mill until the dry mill was taken off line in 1985. The wet milling process was added to reduce dust generation of the milling process. Expansion operations at the former export plant ceased in Libby sometime prior to 1981 although this area was still used to bag and export milled ore until mining operations were stopped in 1990. Before the mine closed in 1990, Libby produced about 80 percent of the world's supply of vermiculite.

Since 1999, EPA Region has been conducting sampling and cleanup activities to address highly contaminated areas in the Libby Valley. The EPA inspection was initiated in response to media articles, which detailed extensive asbestos-related health problems in the Libby population. While at first the situation was thought limited to those with direct or indirect occupational exposures, it soon became clear that there were multiple exposure pathways and many persons with no link to mining-related activities were affected.

Typically, the amphibole asbestos contamination found in the Libby Valley comes from one or some combination of "primary" sources: vermiculite mining wastes, vermiculite ores, vermiculite processing wastes, bulk residuals from vermiculite processing, "LA-containing rocks," or Libby vermiculite attic insulation. Asbestos from these primary sources has been found in interior building dust samples and local soils, which in turn act as secondary sources. To date, the goal of the EPA has been to find and identify areas with elevated levels of asbestos (the primary sources) and to remove them. EPA has conducted contaminated soil removals at the former export plant location, the former screening plant and adjacent properties, and several residential properties with asbestos source materials present. Three schools in the Libby school system have also had removals performed. Details of these operations can be found in the applicable action memorandums.

Cleanup work in Libby is proceeding; the removal of previously identified primary outdoor source areas continues and the removal of VCI from buildings in the Libby Valley is ongoing.

For long-term management purposes, the Libby Asbestos Site has been divided into two OUs: Operable Unit 3 (OU3), which represents the former mine and Rainy Creek Road, and Operable Unit 4 (OU4), which represents the remainder of the Libby Valley. This SAP has been prepared to address cleanup activities associated with OU4 only. Plans for the work associated with OU3 will be addressed under separate cover.

Part I: Field Sampling Plan

Section 3
Sampling Strategy, Locations, and Rationale

The field sampling plan (FSP) is included in Sections 3 and 4. This section describes the overall strategy for sampling conducted during cleanup activities.

3.1 Sampling Strategy

All soil within the demarcated contaminated area will be excavated to the maximum depth of 12 inches in yard or driveway areas and 18 inches in specific use areas (i.e., garden, flowerbed, etc.). Excavation may be terminated at shallow depths if contamination is not found to that depth. This will be determined by the CDM onsite representative.

Following the excavation of the contaminated soils within the demarcated area, the CDM onsite representative will inspect the sidewalls and bottom of the excavation. If there is vermiculite in large quantities still visible in the excavation, the cleanup/ construction contractor will be directed to remove additional contaminated soil until, in the judgment of the CDM onsite representative, the remaining soils are expected to meet soil clearance criteria. At that point, the CDM onsite representative will collect confirmation soil samples.

3.1.1 Soil Confirmation

A confirmation sample will consist of a five-point composite (five sub samples submitted as one sample) surface (0 to 2 inches) soil sample covering an area where contaminated soil has been removed. It will be at the discretion of the CDM onsite representative to decide how many samples will characterize the area being excavated. The number of confirmation samples collected daily will be dictated by the size of the excavation and progress of the cleanup/construction contractor. In general, at least one composite sample will be collected for every 625 square feet of excavation area. Soil sample collection procedures are discussed in Section 4.

3.1.2 Stationary Air Monitoring

During contaminated soil removal, the perimeter of the exclusion zone will be monitored for asbestos fiber migration by collecting stationary air samples at the exclusion zone boundaries. The number and location of the perimeter monitors placed along the exclusion zone boundary will be determined by field personnel after the exclusion zone fencing has been installed by the cleanup/construction contractor. In general, one air sampling location will be located on each side of the excavation for a total of four stationary monitoring locations.

3.1.3 Personal Breathing Zone Monitoring

Personal breathing zone (BZ) air samples will be collected on personnel conducting contaminated soil removal to document that the level of respiratory protection is adequate for the task being conducted. Sampling frequencies for personal BZ air monitoring are established using task-based personal BZ sampling data collected during the 2002 and 2003 field seasons in Libby.

3.2 Quality Assurance/Quality Control (QC) Samples

The QA/QC measures taken for confirmation soil and clearance air sampling include analysis of field and/or laboratory QC samples, verification of analytical results through alternative methods, and laboratory systems audits and performance monitoring through the National Voluntary Laboratory Accreditation Program. Laboratory QA/QC must adhere to method requirements unless defined differently in this SAP. At the discretion of the EPA onsite representative, data generated by polarized light microscopy (PLM) may be verified through alternative analytical methods, which are currently being developed by EPA in a performance evaluation study. If at any point this step is required, direction will be provided in the form of an addendum memorandum or modification form to this SAP.

Individual QA/QC requirements for each sample type are described below. Note that QC samples will not be used in decision making for site cleanup; rather, QC samples will only be used to assess the precision and accuracy of the field sampling and analysis efforts and to understand whether biases exist in the data as a result.

Confirmation Soil Sample QC

Individual QA/QC requirements for confirmation soil samples are:

Field Duplicates. Field duplicate samples are generally collected if information regarding the variability of co-located soil samples is required. As part of the *Contaminant Screening Study* (CDM 2002), field duplicates were collected in order to understand the variability observed in field duplicate samples in Libby soil. For this reason and due to the need for expedited soil sample results, field duplicates are not required for the removal action program.

Performance Evaluation Samples. EPA is currently developing LA in soil performance evaluation (PE) samples for use at Libby. When the PE samples become available, these samples may be inserted into the confirmation soil sample train to independently assess analytical accuracy. If at any point this step is implemented, direction on required frequency, acceptance criteria, corrective action will be provided in the form of an addendum memorandum or modification form to this SAP.

Sample Preparation. Following receipt at the onsite analytical laboratory, soil confirmation samples will be thoroughly homogenized then split. One sample split will be analyzed by the onsite laboratory and the other returned under strict chain of custody to CDM for archival at the CDM Close Support Facility in Denver.

Clearance (Confirmation) Air Sample QC

Individual QA/QC requirements for air samples taken as part of the clearance assessment are defined below and summarized in Table 3-1:

Lot Blanks. Lot blanks are prepared by submitting unused cassettes for analyses prior to putting the group (lot) of cassettes into use. Lot blanks will be collected and analyzed at a frequency of 2 per 100 cassettes from the same lot. The lot blanks will be analyzed by each of the following methods: NIOSH 7400 and TEM AHERA. Lot blanks will be identified on the chain-of-custody (COC) form so that the analytical laboratory is aware of their use and can contact the laboratory coordinator immediately, if asbestos fibers are detected on the filters. If the lot is proved to be contaminated with 7 or more fibers per cubic millimeter by NIOSH 7400, or 1 or more LA structures per square millimeter by TEM AHERA, then the lot of cassettes will be discarded and a new lot of cassettes will be used.

Field blanks should be divided into two categories, those relating to clearance (confirmation) air samples and those relating to other air samples including breathing zone and stationary monitoring. Regardless of the type of field blank, they are all collected by removing the cap from the sample cassette at the time of sampling for not more than 30 seconds and then replacing the cap.

Field Blanks, Clearance Air Samples. Each field team will collect 2 field blanks per work zone (i.e., removal area). The field blanks will come from the same lot as the cassettes used that day for air sample collection. Both of the field blanks will be collected in the removal area, but in the vicinity of the location the ambient air samples are collected. The field blanks will be analyzed by TEM AHERA. If a field blank is contaminated with 1 or more LA structures per square millimeter, then the sample coordinator will contact appropriate personnel to determine whether the occurrence displays a trend in contamination or is isolated. The CDM laboratory coordinator will decide whether analysis of other archived field blanks is necessary. If it is determined that additional archived field blanks require analysis, they will be retrieved from archive at the analytical laboratory and analyzed. Field blank results will be evaluated to determine if field blank contamination is a sample collection procedure deficiency. If at any time field blank contamination appears to be a consistent deficiency in sample collection technique, EPA or its contractors may immediately recommend additional formalized sample collection training and/or an increase in the frequency of field blanks submitted for analysis. If this is implemented, direction on required frequency, acceptance criteria, and corrective action will be provided in the form of an addendum memorandum or modification form to this SAP.

Field Blanks, Breathing Zone/Stationary Air Monitoring Samples. Each field team will collect one field blank per day of air sampling. The field blank cassettes will come from the same lot as the cassettes used that day for air sample collection. One field blank per field team will be analyzed per week. The remainder of the field blanks collected by field teams, but not analyzed, will be submitted to the analytical laboratories marked for archive. The field blanks will be analyzed by each of the following methods: NIOSH 7400 for breathing zone monitoring field blanks or TEM AHERA for stationary monitoring field blanks. The field blanks sample results will be reviewed by the sample coordinator in conjunction with the air sampling field team leader. If a field blank is contaminated with 7 or more fibers per cubic millimeter by NIOSH 7400, or 1 or more LA structures per square millimeter by TEM AHERA, then the sample coordinator will contact appropriate personnel to determine whether the occurrence displays a trend in contamination or is isolated. The CDM laboratory coordinator will decide whether analysis of other archived field blanks is necessary. If it is determined that additional archived field blanks require analysis, they will be retrieved from archive at the analytical laboratory and analyzed. Field blank results will be evaluated to determine if field blank contamination is a sample collection procedure deficiency. If at any time field blank contamination appears to be a consistent deficiency in sample collection technique, EPA or its contractors may immediately recommend additional formalized sample collection training and/or an increase in the frequency of field blanks submitted for analysis. If this is implemented, direction on required frequency, acceptance criteria, and corrective action will be provided in the form of an addendum memorandum or modification form to this SAP.

Table 3-1 QC Sample Requirements for Clearance (Confirmation) Air Samples

QC Sample	Air Sample Type	Frequency	Acceptance Criteria[b]	Corrective Action
Lot Blank	Final Clearance Personal Breathing Zone Stationary	2 per 100 cassettes of the same lot number[a]	1. Analyze & apply acceptance criteria prior to ever using the cassettes for sample collection. 2. <7.0 f/mm^3 (method detection limit using NIOSH 7400) 3. ND for LA (TEM AHERA with site-specific modifications)	Do not use the lot of cassettes for sampling if acceptance criteria are not met.
Field Blank	Final Clearance	2 per work area - 2 field blanks collected per NPE, one will be analyzed and one will be archived	ND for LA (TEM AHERA with site-specific modifications)	Analyze archived blank to determine if contamination on first blank is an isolated occurrence. If the contamination in the field blank does not appear to be a trend, no action is required. If a trend in contamination is apparent, re-train the field team(s) and continue to monitor the problem until resolved. Field blanks contaminated with LA will be considered when determining if the work area meets final clearance criteria (i.e., if recleaning and clearing the work area is warranted).
Field Blank	Breathing Zone Perimeter Monitoring	1 per field team per day of air sampling	1. <7.0 f/mm^2 (Method Detection Limit using NIOSH 7400)[b] 2. ND for LA (TEM AHERA with site-specific modifications)	Evaluate the field blank results to determine if contamination is an isolated occurrence. If the contamination in the field blank does not appear to be a trend, no action is required. If a trend in contamination is apparent, re-train the field team(s) and determine if an increase in the frequency of field blanks analyzed is required. Associated field sample results may be qualified. If necessary, other field blanks collected by the field team should be retrieved from archive and analyzed.

f/mm^2 fibers per square millimeter
ND non-detect for Libby Amphibole
NPE negative pressure enclosure
a Frequency requirements are based on the lot number, not on the air sample type.
b Acceptance criterion is based upon calculations that assume 5.5 fibers per 100 fields analyzed by NIOSH 7400

Section 4
Field Activity Methods and Procedures

The following is a summary of field activities that will be performed by CDM personnel for the process equipment and structure sampling:

- Mobilization
- Procurement of equipment and supplies
- Documentation of field activities
- Photographic documentation
- Field sampling methods and procedures
- Decontamination procedures

4.1 Mobilization

Prior to the mobilization for field activities, a field planning meeting was conducted by the CDM project manager (PM) and attended by the field staff and a member of the CDM QA staff. The agenda was reviewed and approved by the QA staff and the health and safety officer prior to the meeting. The meeting briefly discussed and clarified:

- Objectives and scope of the fieldwork
- Equipment and training needs
- Field operating procedures, schedules of events, and individual assignments
- Required QC measures
- Health and safety requirements
- Documents governing fieldwork that must be on site
- Any changes in the field plan documents

A written agenda, reviewed by the CDM QA staff, was distributed and an attendance list signed. Copies of these documents will be maintained in the project files. Additional meetings will be held when the documents governing fieldwork require it or when the scope of the assignment changes significantly.

The field team personnel will perform the following activities before and during field activities, as applicable:

- Review and understand the FSP, QAPP, and health and safety plan (HASP)
- Ensure that all sample analyses are scheduled through the onsite laboratory
- Obtain required sample containers and other supplies
- Locate hospital
- Obtain and check field sampling equipment
- Obtain personal protective equipment (PPE)
- Turn samples with chain of custody over to the sample coordinator

4.2 Equipment, Supplies, and Sample Containers

The equipment listed below will be required for sampling activities.

Soil sampling:

- Potable water/distilled water
- Field logbook
- Indelible ink pen
- Digital camera
- Sample containers
- Sample paperwork and sample tags/labels
- Custody seals
- Nylon-fiber strapping tape
- Duct tape
- Clear tape
- Plastic 2-gallon baggies (zipper-top)
- Soap
- Garbage bags
- Paper towels
- Scrub brushes
- Coolers
- Bubble wrap
- Plastic samplers (e.g., plastic trowels or scoops)
- Garden sprayer
- PPE

Air sampling:

- SKC low flow pumps
- SKC low flow pump charger
- Primary calibration instrument (dry cal)
- Cassette stands
- 20-inch box fan
- 1 horsepower leaf blower
- 0.8 μm pcm cassettes
- Teflon tape
- Extension cords
- Rotometer
- GFCI three way extension splitter
- Tygon tubing
- 4x6 poly sampling bags
- 9x12 poly sampling bags
- Calculator
- Rubber made storage boxes
- Hard hats
- Kneepads
- Tyvek
- Respirator
- Respirator cartridges
- Flashlight
- Utility knife
- Tape measure
- Compass
- Ballpoint pens
- Permanent markers
- Staple gun
- Duck tape
- Nitrile gloves
- Alcohol wipes
- High volume pumps
- Flow regulators
- Brass barb adapters
- Nylon leur adapter
- 0.45 microvac cassettes
- Clipboard
- Logbooks
- Safety glasses
- Wood chisels
- Spackling
- Scissors
- File tote
- DI water
- Paper towels

4.3 Field Documentation

Information and notations will be recorded as required in the applicable field logbook in accordance with CDM's standard operating procedure (SOP) 4-1, Field Logbook Content and Control (Appendix A). In addition, field sample data sheets (FSDSs) will be completed for each sample in order to capture pertinent tracking information, such as sample date and time, specific location, global positioning system (GPS) identification (if applicable), and logbook reference, for entry into the Libby2 project database. To ensure that sample information is consistent and retrievable from Libby2, all field personnel will be instructed on proper FSDS completion by a member of the sample coordination team prior to field work.

4.4 Field Instrument Calibration and Maintenance

No field measurements will be collected during this inspection and, therefore, no field instruments will be used.

4.5 Photographic Documentation

Photographs will be taken with a digital camera at each sample location and at any place that the field sampling personnel determine necessary. These photographs will be taken in accordance with CDM's SOP 4-2, Photographic Documentation of Field Activities with modification (Appendix A). Electronic photo files will be saved each day to a project-designated computer housed in Libby and named so that photos for a particular property or activity (e.g., bulk insulation removal, interior dust removal, etc.) can easily be retrieved. The photo file naming convention is as follows:

Montana_Ave_45_RM_Attic_Removal_22_110403

Where:

Montana_Ave_45 is the address where removal activities occurred
M designates a removal-related photo (versus other phases of project work)
Attic_Removal defines the activity being documented
22 designates the number of the photo taken at that property that day
110403 designates the date the photo was taken

Following completion of removal activities, all photo files pertaining to a property will be copied onto a CD and filed in Libby along with other property-specific documentation.

4.6 Field Sampling Methods and Procedures

This section provides a list of SOPs, including project-specific SOPs. The project-specific procedure will be followed during this inspection. For additional information, field personnel will refer to the SOPs included in Appendix A and Appendix B (Appendix B provides procedures specific to air sample collection). The HASP should be consulted to determine health and safety protocols for performing site work. Prior to initiating field activities, the field team will review and discuss, in detail, the SAP and HASP.

The contents of each Appendix are listed below.

Appendix A - CDM Standard Operating Procedures (CDM 2002a):

- Sample Custody (SOP 1-2)
- Surface Soil Sampling (Modified SOP 1-3)
- Packaging and Shipping of Environmental Samples (Modified SOP 2-1)
- Guide to Handling of Inspection-Derived Waste (Modified SOP 2-2)
- Field Logbook Content and Control (SOP 4-1)
- Photographic Documentation of Field Activities (Modified SOP 4-2)
- Field Equipment Decontamination at Non-Radioactive Sites (Modified SOP 4-5)
- Completion of Field Sample Data Sheets (FSDS) (project-specific SOP)
- Electronic Chain-of-Custody (project-specific SOP)

Appendix B - Air Sample Collection Procedures:

- EPA SOP 2015; 11/17/94 Revision 0.0, for calibration of all air samples and stationary air sample collection
- 29 CFR 1926.1101 Appendix B; Sampling and Analysis - Non-mandatory, for personal breathing zone air sample collection
- TEM AHERA (40CFR Part 763 Subpart E), for final clearance air sample collection

Appendix C - Analytical Methods:

- PCM (NIOSH 7400 Issue 2), for personal breathing zone air sample analysis
- PLM (NIOSH 9002 Issue 2), for soil confirmation samples

Appendix D - Request for Modification Form:

- Record of Deviation/Request for Modification Form

4.7 Decontamination Procedures

Sampling methods have been selected to reduce the amount of equipment that needs to be decontaminated (i.e., by choosing either dedicated or disposable items). If a piece of equipment needs to be used to collect more than one sample (i.e., comes into contact with more than one sample material), that piece of equipment will be decontaminated in accordance with CDM SOP 4-5, Field Equipment Decontamination at Nonradioactive Sites with modification and confirmation soil sampling procedures (Appendix A).

Part II: Quality Assurance Project Plan

Section 5
Project Management

This SAP supports the draft RAWP for the Libby site. This SAP was prepared in accordance with EPA *Requirements for Quality Assurance Project Plans for Environmental Data Operations*, QA/R-5, Final (EPA 2001). This section covers the basic area of project management, including the project organization, background and purpose, project description, quality objectives and criteria, special training, and documentation and records. Appendix A includes a copy of applicable CDM SOPs (CDM 2002b) while Appendix B includes air sample collection procedures.

5.1 Project Organization

Organization and responsibilities specific to this study are discussed in this section. CDM will provide the necessary technical and field staff to perform sampling and reporting aspects of the project. Analytical services are provided through a Volpe or CDM subcontract laboratory.

5.1.1 EPA Region VIII Management

The EPA remedial project manager (RPM), Mr. Jim Christiansen, is CDM's primary contact for coordinating draft response action work at the Libby Asbestos Site. Mr. Christiansen, as RPM, is responsible for the management and coordination of the following activities:

- Defining the scope of the draft response action
- Defining data quality objectives
- Reviewing all project deliverables
- Maintaining communications with the CDM project manager for updates on the status of the draft response action activities

5.1.2 Volpe Management

The Volpe project manager (PM), Mr. John McGuiggin, is CDM's primary contact for coordinating draft response action work at the Libby Asbestos Site. Mr. McGuiggin, and Ms. Courtney Zamora, as site manager, are responsible for the management and coordination of the following activities:

- Defining the sampling scope for this inspection
- Defining data quality objectives
- Reviewing all project deliverables
- Reviewing monthly status reports
- Providing oversight of the sampling
- Assuring that plans are implemented properly

- Informing personnel of any special considerations associated with the project
- Providing site access, if necessary
- Reviewing work progress for each task
- Reviewing and analyzing overall performance with respect to goals and objectives

Mr. Mark Raney at Volpe is the Libby2 project database manager. Mr. Raney is responsible for overseeing various support personnel at Volpe and CDM to maintain and update the structure of the Libby2 database as project needs arise. Mr. Raney also works closely with the project laboratory coordinator, sample coordinator, contract laboratories, and sample tracking database manager to ensure timely and correct population of the Libby2 database.

5.1.3 CDM Management

The CDM management team will be comprised of the following positions: Libby project manager (PM), construction manager, air monitoring manager, sample coordinator, field health and safety coordinator, and project quality assurance coordinator.

The following personnel are assigned to this project:

Project Manager	Tim Wall
Field Construction Manager	Scott Supernaugh
Construction Oversight Staff	Tom Vanderweel
	Dean Kozlowski
	Brian Pyles
Sample Coordinator	Terry Crowell
Field Health and Safety Coordinator	Shawn Oliveira
Air Monitoring Manager	Greg Parana
Quality Assurance Manager	George DeLullo
Project Quality Assurance Coordinator	Krista Lippoldt
Laboratory Coordinator	Anni Autio
Sample Tracking Database Manager	Dave Knight

The CDM PM for this inspection sampling is Tim Wall. Mr. Wall, as PM, is responsible for the overall management and coordination of the following activities:

- Maintaining communications with EPA and Volpe regarding the status of this project

- Supervising production and review of deliverables

- Reviewing analytical results

- Tracking of planned budgets and schedules

- Incorporating and informing EPA of changes in the work plan, SAP, HASP, and/or other project documents
- Procuring non-laboratory subcontractors, when necessary
- Providing oversight of data management
- Using sampling data in site remediation decisionmaking

The CDM construction manger for this inspection sampling is Scott Supernaugh. Mr. Supernaugh, as construction manager, is responsible for the overall management and coordination of the following activities:

- Preparing monthly status reports
- Reviewing analytical results
- Overseeing operation and maintenance activities
- Notifying the responsible QA staff immediately of significant problems affecting the quality of data or the ability to meet project objectives
- Scheduling personnel and material resources
- Implementing field aspects of the inspection, including this SAP and other project documents
- Organizing and conducting periodic meetings with onsite facility personnel
- Implementing the QC measures specified in CDM's *Quality Management Plan (QMP)* (CDM 2003a), this QAPP, and other project documents
- Implementing corrective actions resulting from staff observations, QA/QC surveillances, and/or QA audits
- Providing oversight of daily and periodic report preparation
- Coordinating work activities including sampling
- Ensuring that sampling is conducted in accordance with pertinent CDM SOPs and that the quantity and location of all samples meet the requirements of this SAP
- Scheduling and conducting required sampling and monitoring activities

Ms. Terry Crowell of CDM will be the sample coordination field team leader. Ms. Crowell is responsible for the following:

- Ensuring electronic data entry from FSDSs into the onsite sample tracking database (*eLASTIC*)
- Generating COC forms and ensuring adherence to sample custody procedures (e.g., use of custody seals by the samplers)
- Preparing and shipping samples to the analytical laboratories
- Providing electronic sample information to Volpe for Libby2 database population
- Coordinating with the laboratories regarding sample deliveries/shipments and following up with result reporting
- Receiving and distributing air monitoring and soil confirmation sample results to the onsite health and safety officer and removal oversight personnel as applicable
- Receiving and distributing fill material sample results to the construction manager and data evaluators for review purposes

Ms. Crowell is also responsible for ensuring transmittal of project documentation to Volpe and to the file repositories in Helena and Denver.

The construction oversight personnel, Mr. Tom Vanderweel, Mr. Dean Kozlowski, and Mr. Brian Pyles, will conduct soil sampling. The air-monitoring manager, Mr. Greg Parana, will conduct air sampling per the RAWP and in accordance with procedures presented herein. The field health and safety coordinator is Shawn Oliveira. All work will be conducted in accordance with the site-specific HASP that governs the field activities outlined in this SAP. Mr. Oliveira, as the field health and safety leader, is responsible for ensuring that the protocols specified in the HASP are carried out during field activities. He will also ensure that copies of the HASP are maintained at the Site at all times. He is responsible for the upgrading or downgrading of the level of protection in accordance with the HASP, based on the existing site conditions. The field health and safety coordinator must conduct an initial health and safety meeting, providing an overview of the HASP to all assigned field personnel, and have them sign a form to indicate they understand the content of the HASP document and will adhere to its specifications. He will contact the CDM health and safety coordinator if any questions or issues arise during field activities.

The laboratory coordinator is Ms. Anni Autio. As such, Ms. Autio is responsible for the procurement of laboratories subcontracted by CDM. In addition, she will ensure that all laboratories meet project requirements for data reporting.

Mr. Dave Knight is the database manager for the onsite sample tracking database (*eLASTIC* database). In this capacity, Mr. Knight is responsible for the development and maintenance of the onsite database to ensure project tracking needs are met. Mr. Knight's responsibilities also include working with the Volpe Libby2 database manager and other Volpe and CDM support staff to ensure consistency between the two project databases (i.e., architecture).

5.1.4 Quality Assurance Organization

CDM's QA manager, Mr. George DeLullo, implements the QA program. The QA manager is independent of the technical staff and reports directly to the president of CDM on QA matters. The QA manager thus has the authority to objectively review projects and identify problems and the authority to use corporate resources as necessary to resolve any quality-related problems.

The QA coordinator for this project, Ms. Krista Lippoldt, reports to the QA manager on QA matters. Under the oversight of the QA manager, she is responsible for the following:

- Verifying that corrective actions resulting from staff observations, QA/QC surveillances, and/or QA audits are implemented
- Reviewing and approving the project-specific plans
- Directing the overall project QA program
- Maintaining QA oversight of the project
- Reviewing QA sections in project reports, as applicable
- Reviewing QA/QC procedures applicable to this project
- Auditing selected activities of this project performed by CDM and subcontractors, as necessary
- Initiating, reviewing, and following up on response actions, as necessary
- Maintaining awareness of active projects and their QA/QC needs
- Consulting with the CDM QA manager, as needed, on appropriate QA/QC measures and corrective actions
- Conducting internal system audits to check on the use of appropriate QA/QC measures, if applicable
- Arranging performance audits of measurement activities, as necessary
- Providing monthly written reports on QA/QC activity to the CDM QA manager

5.1.5 Report Organization

This SAP is organized in accordance with EPA QA/R-5 guidance for preparing SAP (EPA 2001). This section (Section 5) presents project management and introductory information. Section 6 provides guidance for measurement and data acquisition. Section 7 describes assessment and oversight aspects of the project, and Section 8 describes data validation and usability issues. References are provided in Section 9.

5.2 Background and Purpose

Site background and a description of the process equipment and structures are provided in Section 2 of this SAP. The purpose and objectives of this inspection are discussed in Section 1.1 of this SAP. The purpose of this SAP is to provide guidance to ensure that all environmentally related data collection procedures and measurements are scientifically sound and of known, acceptable, and documented quality and conducted in accordance with the requirements of the project.

5.3 Project Description

A description of this project is provided in Section 1 of this SAP. Samples will be analyzed for parameters listed in Section 5.4. Sampling activities and all associated procedures are described in detail in this SAP.

5.4 Quality Objectives and Criteria for Measurement

This section provides internal means for control and review of the project so that environmentally related measurements and data collected are of known and acceptable quality. The subsections below describe the data quality objectives (DQOs) (Section 5.4.1) and data measurement objectives (Section 5.4.2).

5.4.1 Data Quality Objectives

To accomplish the project goals, the RAWP/SAP calls for the sampling and analysis of a variety of media for various purposes. For convenience and to clarify the specific purpose of each sampling and analysis program, the DQOs are organized separately by medium and respective purpose. Whenever possible, this is accomplished in tabular form. As shown, the various DQOs are segregated into the following: (1) Soil Confirmation Samples, (2) Personal Air (BZ) Samples, (3) Perimeter Monitoring Air Samples, (4) Air Confirmation for VCI Removal, and (5) Air Confirmation for Indoor Dust Removal.

Step 1: State the Problem

Identify the planning team members including the decision makers:

All project personnel are detailed in Section 5.1. The decision makers for the activities described in this RASAP are Jim Christiansen (EPA RPM), John McGuiggin (Volpe PM), and Tim Wall (CDM PM).

Describe the problem:

Previous studies such as the CSS and the Pre-Design Remedial Inspections were designed to characterize LA contamination at residential and commercial properties in and around Libby. Removal activities will be performed at residential and commercial properties that have been found to contain LA asbestos-contaminated VCI, interior dust, and/or exterior soils. During removal activities on those properties (i.e., excavation of contaminated soil), the potential for LA fibers to migrate offsite increases. Likewise, during these activities, the potential for LA exposure to workers is also increased. Therefore, it is important to ensure worker safety and contaminant containment through periodic monitoring. Following cleanup, confirmation samples must be collected and analyzed expeditiously to determine if the removal actions met project goals. Therefore, a program must be put in place to monitor: (1) worker exposure and contaminant containment during removal activities; and (2) the effectiveness of the cleanup (i.e., confirmation) following removal activities.

Determine resources:

CDM's current task order under Volpe provides a detailed description of resources, budget, and schedule for sampling and analysis response activities.

Step 2: Identify the Decision

Identify the principle study question, alternative actions, and decision statements:

The principle study question(s), alternative actions, and decision statements are summarized in Table 5-1.

Table 5-1 Identify the Decision

Data Quality Objective	Sample Description	Principle Study Question(s)	Alternative Actions	Decision Statements
RA Monitoring	Personal (BZ) Air Monitoring	Is LA detected in the workers' breathing zone above worker safety limits?	1. Continue contaminated soil and/or VCI removal and re-evaluate engineering controls, work practices, and/or PPE 2. Stop work 3. Take no action	Are LA fibers collecting in the workers' breathing zone above worker safety limits? If yes, engineering controls, work practices, and/or PPE will be re-evaluated and/or work will stop. If no, cleanup activities will continue with no additional evaluation.
RA Monitoring	Perimeter Air Monitoring	Are LA fibers detected in air along the perimeter of the exclusion zone boundary of an exterior cleanup site?	1. Continue contaminated soil removal and re-evaluate engineering controls and work practices 2. Take no action	Are LA fibers migrating to the exclusion zone boundary during LA contaminated soil removal? If yes, engineering controls and/or work practices, will be re-evaluated and/or work will stop. If no, excavation activities will continue with no additional evaluation.
RA Confirmation	Soil Confirmation	Is LA detected in the soil surface of the excavated area, after soil removal? If so, has the maximum excavation depth of 12 or 18 inches been achieved (yard soil/driveway or specific use areas, respectively)? [a]	1. Excavate additional soils 2. Stop excavation and designate as either a non-contaminated area or an area of no further removal action	If LA is detected, and – Max. excavation depth <u>is not</u> achieved: 1. Excavate additional soils 2. Continue until no LA is detected or max. excavation depth achieved 3. Stop excavation and designate as a non-contaminated area (if [LA] is ND) Max. excavation depth <u>is</u> achieved: 1. Continue excavating additional soils IF LA 1% 2. Stop excavation and designate as either a non-contaminated area (if [LA] is ND) or an area of no further removal action (if [LA]<1%)

Table 5-1 Identify the Decision

Data Quality Objective	**Sample Description**	**Principle Study Question(s)**	**Alternative Actions**	**Decision Statements**
RA Confirmation	Air Confirmation for VCI Removal	Is LA detected in the air within an NPE where VCI was removed?	1. Re-clean NPE space 2. Take no action	Does the air in the space that previously contained VCI contain LA fibers, after removal activities above desired levels? If yes, the area will be re-cleaned. If no, the area will be deemed non-contaminated.
RA Confirmation	Air Confirmation for Indoor Dust Removal	Is LA detected in the air within an NPE after the removal of LA-contaminated dust?	1. Re-clean NPE space 2. Take no action	Does the air in the space that was previously contaminated with LA in the indoor dust contain LA above desired levels? If yes, the area will be re-cleaned. If no, the area will be deemed non-contaminated.

RA Removal Action
BZ Breathing Zone
NPE Negative Pressure Enclosure
PPE Personal Protective Equipment
[a] A specific use area is defined as a garden, former garden, planter, or other defined area of a yard likely to receive significant use and generally not covered

Step 3: Identify the Inputs to the Decision

Identify the information needed. Determine the basis for determining the Action Levels. Identify sampling and analysis methods that can meet the data requirements.

The information needed for the decision, the action levels, the basis for the action levels, and analytical method summaries are provided in Table 5-2.

This RAWP/SAP is designed only for cleanups for which LA characterization at a property (e.g., soil concentration, indoor dust levels, etc.) has been performed through another SAP (either the CSS or the RI studies). Analytical results (that are confirmatory and do not serve to characterize contamination) are needed within hours of sampling so that excavation/cleanup work may continue with relative continuity. As such, confirmation soil samples will not be ground as in previous characterization studies and will be analyzed via PLM NIOSH 9002. Further, analyses will generally be performed at the mobile laboratory in Libby to ensure expedited results.

Table 5-2 Inputs to the Decision

Data Quality Objective	Sample Description	Information Needed	Action Level	Basis for Action Level	Analytical Method
RA Monitoring	Personal Breathing Zone Air Monitoring	Reported Result: AS_{PCM}: 1 f/cc AS_{TEM}: 0.005 S/cm^3 Min. Volume: 25 L[a] Collect: TWA: 8-hour TWA STEL: 30-minute excursion sample	TWA: 0.1 PCME f/cc STEL: 1.0 f/cc	OSHA Worker Safety Regulations (1926.1101)	PCM: NIOSH 7400 TEM[d]: TEM AHERA with site-specific modifications
RA Monitoring	Perimeter Air Monitoring	AS_{TEM}: ~0.005 S/cm^3 Min. Volume: 1200 L Collect: 4 samples, min. along north, south, east & west boundaries of EZ	Each air sample <AS_{TEM} Approx. <0.005 S/cm^3	Removal Action Clearance Criteria[b]	TEM AHERA with site-specific modifications
RA Confirmation	Soil Confirmation	Reported Result: % LA by VAE AS: Method defined as 1%, but qualitative estimates of LA present below 1% reported as <1% or ND Approx. Mass: 1 kilogram	Up to max. cleanup depth of 12 or 18 inches (yard soils/driveway or specific use areas, respectively): ND Below max. cleanup depth: <1% LA by VAE[a,b]	Removal Action Clearance Criteria[b,c]	Analysis: NIOSH 9002
RA Confirmation	Air Confirmation for VCI Removal	AS_{TEM}:~0.005 S/cm^3 Min. Volume: 1200 L Collect: 5 samples of disturbed air within NPE	Average of 5 samples of disturbed air collected in the attic indicate <0.005 S/cm^3	Removal Action Clearance Criteria[b]	TEM AHERA with site-specific modifications
RA Confirmation	Air Confirmation for Indoor Dust Removal	AS_{TEM}:~0.005 S/cm^3 Min. Volume: 1200 L Collect: 5 samples of disturbed air within NPE	Each of 5 samples of disturbed air <AS_{TEM} Approx. <0.005 S/cm^3	Removal Action Clearance Criteria[b]	TEM AHERA with site-specific modifications

Table 5-2 Inputs to the Decision

Data Quality Objective	Sample Description	Information Needed	Action Level	Basis for Action Level	Analytical Method

AS	Analytical Sensitivity
L	Liters
RA	Response Action
ND	Non-detect
VAE	visual area estimation
f/cc	*fiber per cubic centimeter*
S/cm^3	Libby Amphibole structures per cubic centimeter of air
TEM AHERA	All samples are analyzed by transmission electron microscopy using the counting method as described in the Asbestos Hazard Emergency Response Act (AHERA) (EPA 1987) with site-specific modifications
NPE	negative pressure enclosure
[a]	Minimum volume requirements according to the method are 25 L. However, in order to achieve a reasonable analytical sensitivity by TEM, the sampler should attempt to collect 400 L of air for the BZ sample.
[b]	Action Level/Clearance Criteria Technical Memorandum (EPA 2003a).
[c]	As stated in the technical memorandum (EPA 2003b) efforts will be made to avoid having to repeat cleanup activities at a property by cleaning soils at the residential or commercial property to ND up to the maximum cleanup depth of 12 or 18 inches (yard soil/driveway or specific use areas, respectively). Excavation beyond the maximum cleanup depth will only continue if soils have concentrations 1% LA.
[d]	If PCM results are above the OSHA PEL, TEM AHERA confirmation must be performed.
[e]	Approximately 0.5 kg for analysis and 0.5 kilogram for archival

Step 4: Define the Study Boundaries

Define the target population, spatial and temporal boundaries, potential constraints, and the smallest subpopulation.

The target population, spatial and temporal boundaries, potential constraints, and the smallest subpopulation are summarized in Table 5-3.

Table 5-3 Study Boundaries

RA Monitoring	Personal Breathing Zone Air Monitoring	Ambient air within the workers' breathing zone; during removal activities	Each individual worker's breathing zone for the task performed	Collected during exterior or interior removal activities (i.e., excavation, VCI removal, interior cleaning)	NA	1 air sample for each Level C task (e.g., laborer, bulk removal, operator, etc.) per week.
RA Monitoring	Perimeter Air Monitoring	Ambient air at the boundary of the EZ; during removal activities	Vertical: Air space above the exclusion zone to sampling height (~4-6 feet) Horizontal: perimeter bounding the site-specific EZ	Collected during exterior removal activities (i.e., excavation)	Inaccessibility due to property boundaries or other obstacles Inclement weather such as rain that can cause the sample to be void[c]	4 air samples that bound the EZ
RA Confirmation	Soil Confirmation	Surface soil at the bottom of the excavation site; after soil removal activities	Vertical[a]: Yard Soils: 12 inches bgs to ground surface Specific Use Areas: 18 inches bgs to ground surface Horizontal: site-specific EZ	Collected after all contaminated soil is excavated and removed from the site and will continue until the area is designated as either non-contaminated or removal actions are discontinued (no further action)	No soil available for sampling because excavation continued to bedrock	1 soil sample for every 250 ft^2 excavated
RA Confirmation	Air Confirmation for VCI Removal	Ambient air within the space that previously contained VCI; after removal activities	Vertical: Floor surface to the ceiling of the space that contained VCI Horizontal: air space contained within the area/NPE where VCI was removed	Collected after all VCI is removed from the functional space that contained VCI and will continue until the area is designated non-contaminated	NA	5 air samples (cartridges) per EZ/functional space

Table 5-3 Study Boundaries

RA Confirmation	Air Confirmation for Indoor Dust Removal	Ambient air within the living or functional space that was previously contaminated with LA; after removal activities	Vertical: Floor surface to the ceiling of the living or functional space that had LA contamination Horizontal: air space contained within the area/NPE where LA dust was removed	Collected after all LA is removed from the living or functional space that contained LA and will continue until the area is designated non-contaminated	NA	5 air samples (cartridges) per EZ/functional space

EZ Exclusion Zone
RA Removal Action
bgs below ground surface
NA not applicable
[a] These are generally the vertical boundaries for soil. If LA contamination 1% is found, the vertical boundary shall be extended for that location until the concentration is below 1% LA, to a maximum depth of 3 feet. If gross contamination is encountered at this depth, excavation will continue until the gross contamination is removed.
[b] A general schedule/timeline for cleanups is provided in the RAWP. This section is specific to timeframes for sampling at a particular property and/or exclusion zone.
[c] If it is raining, attempts will be made to protect the sample from moisture.

Step 5: Develop a Decision Rule

Population Parameter, Action Levels, Decision Rule:

The population parameter, action levels, and decision rules are summarized in Table 5-4.

Table 5-4 Decision Rule

Data Quality Objective	Sample Description	Population Parameter	Action Level	Decision Rule
RA Monitoring	Personal Breathing Zone Air Monitoring	1 air sample representing the breathing zone for the activity conducted	TWA: 0.1 PCME f/cc STEL: 1.0 f/cc	If the concentrations of the BZ samples 0.1 f/cc engineering controls, work practices, and/or PPE will be re-evaluated and/or work will stop. If no, cleanup activities will continue with no additional evaluation.
RA Monitoring	Perimeter Air Monitoring	4 air monitoring samples that bound the perimeter of the EZ	Each air sample <AS_{TEM} Approx. <0.005 AHERA S/cm^3	If the concentration of any of the 4 samples 0.005 S/cm^3, then excavation engineering controls and work practices will be re-evaluated and/or work will be stopped. If all 4 perimeter air samples are ND, then no action will be taken.
RA Confirmation	Soil Confirmation	Soil sample representing the area of excavation, per 250 ft^2	Up to max. cleanup depth of 12 or 18 inches (yard soils/driveway or specific use areas, respectively): ND Below max. cleanup depth: <1% LA by VAE[a,b]	If LA is detected, and – Max. excavation depth <u>is not</u> achieved: 1) Excavate additional soils at approx. 6 inch intervals 2) Continue until no LA is detected or max. excavation depth achieved 3) Stop excavation and designate as a non-contaminated area (if [LA] is ND) Max. excavation depth <u>is</u> achieved: 1) Continue excavating additional soils at the discretion of the CDM oversight representative IF [LA] 1% 2) Stop excavation and designate as either a non-contaminated area (if [LA] is ND) or an area of no further removal action (if [LA]<1%)
RA Confirmation	Air Confirmation for VCI Removal	Sum of all fibers observed on 5 confirmation samples, per NPE	Average of 5 samples of disturbed air collected in the attic indicate <0.005 S/cm^3	If the average concentration of the 5 samples of disturbed air is 0.01 AHERA s/cm^3, then the functional space will be re-cleaned and subsequently re-sampled. If the average concentration of the 5 samples of disturbed air <0.01 AHERA s/cm^3, the functional space will be designated non-contaminated.

Table 5-4 Decision Rule

Data Quality Objective	Sample Description	Population Parameter	Action Level	Decision Rule
RA Confirmation	Air Confirmation for Indoor Dust Removal	Sum of all fibers observed on 5 interior cleaning confirmation samples, per NPE	Each of 5 samples of disturbed air less than AS_{TEM} ~ <0.005 S/cm^3	If the concentration of any of the 5 samples of disturbed air is 0.005 S/cm^3, then the living or functional space will be re-cleaned and subsequently re-sampled. If the concentration of any of the 5 samples of disturbed air <0.005 S/cm^3, the living or functional space will be designated non-contaminated.

EZ Exclusion Zone
RA Removal Action
PCME PCM Equivalent
TWA Time Weighted Average
[a] Action Level/Clearance Criteria Technical Memorandum (EPA 2003a).
[b] As stated in the technical memorandum (EPA 2003b), efforts will be made to avoid having to repeat cleanup activities at a property by cleaning soils at the residential or commercial property to ND up to the maximum cleanup depth of 12 or 18 inches (yard soil/driveway or specific use areas, respectively). Excavation beyond the maximum cleanup depth will only continue if soils have concentrations 1% LA

Step 6: Specify Tolerable Limits on Decision Errors

Null Hypotheses, consequence of making an incorrect decision, gray region, tolerable limits:

For the purposes of completing all six steps of the DQO process, the null hypotheses and consequences of making an incorrect decision are summarized in Table 5-5. However, the gray region and tolerable limits on decision errors are not proposed because they are not applicable in this case.

Typically, Step 6 of the DQO process is useful to encourage careful design of decision rules by defining and integrating the errors that are acceptable based upon a myriad of integrated project management decisions such as reduction in risk to human health, implementability/practability, and cost. As stated in the guidance document for development of DQOs: QA/G-4 (EPA 2000), solely statistically generated tolerable limits on decisions errors are not necessary in certain cases providing a line of reasoning (scientific justification) is presented that adequately defines acceptable limits or decision errors. This particular effort was put forth in the Action Level/Clearance Criteria Technical Memorandum for the following DQOs: (1) Soil Confirmation Samples, (2) Perimeter Monitoring Air Samples, (3) Air Confirmation for VCI Removal, and (4) Air Confirmation for Indoor Dust Removal. The decision rule for the personal (BZ) air monitoring samples has been promulgated by legislation, and as such, limits on decision errors do not apply.

Table 5-5 Limits on Decision Errors

Data Quality Objective	Sample Description	Null Hypothesis	Type I Error Will Result in:	Type II Error Will Result in:
RA Monitoring	Personal (BZ) Air Monitoring	The BZ air is contaminated with LA above the worker safety action levels.	determining that the BZ air is not contaminated with LA above the worker safety action levels when it actually is. This in turn, results in an increased risk to workers performing removal actions.	determining that the BZ air is contaminated with LA above the worker safety action levels when it is not. This in turn, results in re-evaluating engineering controls, possibly stopping work, or increasing the level of PPE when it is not necessary and adds unnecessarily to cleanup costs.
RA Monitoring	Perimeter Air Monitoring	The perimeter air is contaminated with LA.	determining that the perimeter air is not contaminated with LA when it actually is. This in turn, results in an increased risk to human health.	determining that the perimeter air is contaminated with LA when it is not. This in turn, results in re-evaluating engineering controls and possibly stopping work when it is not necessary, and adds unnecessarily to cleanup costs.
RA Confirmation	Soil Confirmation	The soils below an excavation are still contaminated with LA after removal.	determining that the surface soils at the bottom of the excavated area are not contaminated with LA when they actually are. This in turn, results in an increased risk to human health.	determining that the surface soils at the bottom of the excavated area are contaminated with LA when they are not. This in turn, results in excavation of additional soils when it is not necessary and adds unnecessarily to cleanup costs.
RA Confirmation	Air Confirmation for VCI Removal	The functional space that contained VCI prior to removal is still contaminated with LA after removal.	determining that the NPE that previously contained VCI is not contaminated with LA after removal when it actually is. This in turn, results in an increased risk to human health.	determining that the NPE that previously contained VCI is contaminated with LA after removal when it is not. This in turn, results in unnecessary re-cleaning of the NPE and adds unnecessarily to cleanup costs.
RA Confirmation	Air Confirmation for Indoor Dust Removal	The living or functional space that was previously contaminated with LA is still contaminated with LA after removal.	determining that the NPE that was previously contained LA-laden dust is not contaminated with LA after removal when it actually is. This in turn, results in an increased risk to human health.	determining that the NPE that previously contained LA-laden dust is contaminated with LA after removal when it is not. This in turn, results in unnecessary re-cleaning of the NPE and adds unnecessarily to cleanup costs.

NA Negative Pressure Enclosure
RA Removal Action
PPE Personal Protective Equipment

Step 7: Optimize the Design for Obtaining Data

Using data previously generated for the site, the DQOs have been designed to support the proposed removal activities for the RAWP and represents the best possible project planning effort. However, in implementing the RAWP/SAP, unforeseen situations may arise or team members may find more efficient means to carry out some of the day-to-day activities. Therefore, team members are always afforded the opportunity to recommend optimization of the data gathering design. Recommendations must come through proper channels as described in Section 5.1 and documented using either a modification form or an addendum to the RAWP. All modifications or addendums must be approved prior to making the proposed changes.

5.4.2 Data Measurement Objectives

Every reasonable attempt will be made to obtain a complete set of usable field measurements and analytical data. If a result cannot be obtained or is rejected for any reason, the effect of the missing data will be evaluated by CDM and transmitted to EPA immediately. In addition, the FSP provides guidance to ensure that the samples obtained are representative of the media at the Site.

5.4.2.1 Quality Assurance Guidance

The field QA program has been designed in accordance with CDM's *QMP* (CDM 2003), EPA's *Guidance for the DQO Process* (EPA 2000), and the EPA *Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 2001).

5.4.2.2 Field Measurements

No field measurements are conducted during this inspection, therefore, no calibrations or maintenance are required.

5.4.2.3 Laboratory Analysis

Samples collected under this QAPP will be analyzed for parameters listed below using methods in parentheses. The analytical methods are as follows:

- Soil clearance samples - PLM (NIOSH 9002 Issue 2)
- Personal air samples - PCM (NIOSH 7400 Issue 2)
- Stationary air samples - TEM AHERA (40CFR Part 763 Subpart E)
- Air clearance samples - TEM AHERA (40CFR Part 763 Subpart E)

Samples will be submitted to CDM's subcontract laboratories. Prior to shipping samples, sampling personnel will ensure that the laboratories are ready to receive and analyze samples, can provide necessary data packages, and can provide an electronic copy of the data. The laboratories will submit analytical data reports to CDM. The data reports will contain a case narrative that briefly describes the number of samples, the analyses, and any noteworthy analytical difficulties or QA/QC issues associated with the submitted samples. The data report will also include signed COC forms, cooler receipt forms, analytical data, and a QC package. The laboratories will provide an electronic copy of the data to CDM.

Analytical Sensitivity and Reporting Limits
The reporting limits provided in Table 5-1 are the minimum levels that the laboratories will report without a qualifier. If the result is between the instrument detection limit (IDL) and the reporting limit, the value will be reported as an estimated concentration and qualified by the laboratories. The achievement of reporting limits depends on sample matrix effects and the IDL. The IDL depends on instrument sensitivity. It is therefore important for the laboratories to monitor the sensitivity of data-gathering instruments to ensure data quality through constant instrument performance checks. Because the reporting limits may vary based on the IDL, the values provided in Table 5-1 are estimates and may change based on laboratory-specific circumstances.

Holding Times and Preservation
Holding times are storage times allowed between sample collection and sample analysis (and extraction) when the designated preservation and storage techniques are employed. Method of shipment must be considered to meet required holding times. Holding times for each analytical method used in this study are provided in Table 3-1.

Laboratory Quality Assurance Program
The laboratories must be NVLAP (National Voluntary Laboratory Accreditation Program) certified and must follow the NVLAP QA program requirements. In addition, the laboratories performing analyses must follow all project-specific analytical and QA/QC modifications and must continue to participate in the project-specific analysis of performance evaluation samples, interlaboratory samples, same and different analyst recounts, verified analyses, and laboratory duplicates at the project-specified frequencies.

5.5 Special Training Requirements

Special training required for this study include the following:

- Health and safety training, as described in the HASP

5.6 Documentation and Records

CDM's administrative staff in Helena has the responsibility for maintenance of records, including copies of all FSDSs, original field logbooks, work plans and SAPs, and any correspondence pertinent to conducting removal activities at the site. Original FSDSs are maintained in the Libby CDM office in the event that sample information needs to be updated or corrected. Revisions to FSDSs will be made using a single strikeout, initial, and date. Copies of FSDSs, including revised forms, will be shipped to Volpe (to the attention of Mr. John McGuiggin) on a daily basis and the project files weekly using a courier service. Because field logbooks are not to be revised, original logbooks are shipped offsite to the Helena secure file repository and copies maintained for reference in Libby. These are shipped to Helena weekly using a courier service. Property surveys, if required, are maintained in the Libby CDM office.

Project personnel are responsible for project documents in their possession while working on a particular task. Field logbook(s) are issued on an as-needed basis. An index that tracks logbook number, logbook title, date of issue, and name of issuee, is maintained in the Libby CDM office and provided to CDM Helena staff along with weekly shipments of original logbooks.

Documentation describing changes to approved field plans or sample preparation or analytical methods, if they occur, will be included in the project files in the form of an approved Request for Modification form. Blank field and laboratory Request for Modification forms are provided in Appendix B. Request for Modification forms will be initiated by CDM or laboratory personnel and reviewed/approved by authorized EPA and Volpe representatives. Original forms with EPA and Volpe signatures will be maintained in the Libby CDM office (for field plan changes) and at Volpe (for laboratory procedure changes), with copies distributed to the file repositories. Approved modifications to sample preparation and analytical methods to date are presented in CDM 2003b.

The laboratories will submit hard copy sample data packages to the CDM laboratory coordinator, and electronic data deliverables (EDDs) to Volpe, the laboratory coordinator, and the sample coordinator. The onsite laboratory will also report sample results via facsimile to the sample coordinator.

Section 6
Measurement and Data Acquisition

This section covers sample process design, sampling methods requirements, handling and custody, analytical methods, QC, equipment maintenance, supply acceptance, and data management. The field procedures are designed so that the following occurs:

- Samples collected are consistent with project objectives
- Samples are collected in a manner so that data represent actual site conditions

6.1 Sample Process Design

The overall goal of the sampling is to monitor: (1) worker exposure and contaminant containment during removal activities; and (2) the effectiveness of the cleanup (i.e., confirmation) following removal activities. This will be accomplished by collecting personal air (BZ) samples and stationary monitoring samples during removal activities and by collecting the following samples after removal: soil confirmation, air confirmation samples for VCI removal, and air confirmation samples for indoor dust removal. The sample process design is discussed in Section 3 of this SAP.

6.2 Sampling Methods Requirements

Sampling methods, sample containers, and overall field management are described below.

6.2.1 Sampling Equipment and Preparation

Equipment required for the field inspection for sampling, health and safety, documentation, and decontamination is presented in Sections 4.3 through 4.5 of the FSP.

Field preparatory activities include review of this SAP and SOPs, procurement of field equipment, laboratory coordination, and a daily field planning meeting that includes field personnel, a health and safety representative, a QA staff member. Mobilization is described in Section 4 of the FSP.

6.2.2 Sample Containers

All confirmation soil samples and air samples will be collected and placed into plastic zip-lock baggies.

6.2.3 Sample Collection, Handling, and Shipment

Samples collected during the study consist of air and soil, and QC samples. All sample collection procedures are outlined in Section 4 of the FSP, and CDM and other SOPs as provided in Appendix A to this document. The SOPs applicable to this inspection are provided in Appendix A. QC samples will also be collected, handled, and shipped in accordance with these procedures.

6.3 Sample Handling and Custody Requirements

Custody and documentation for field and laboratory work are described below, including a discussion of corrections to documentation.

6.3.1 Field Sample Custody and Documentation

Sample custody and documentation will follow the requirements specified in CDM's SOP 1-2, Sample Custody, and site-specific SOPs for completion of FSDS and electronic COC forms (Appendix A). All samples and sampling paperwork will be relinquished to the sample coordinator at the end of each day. The sample coordinator will be responsible for managing all field forms. The distribution of field paperwork is discussed in Section 5.6.

Upon completion of the FSDS by the sampler and a subsequent quality control check by an independent field team member, the sample coordinator will use the FSDS to generate a COC. Three copies of the COC will then be printed using three-part carbonless paper. One copy will be filed in the Libby CDM office and the other two will accompany sample shipments. The sample coordinator will check the COC against the samples in the shipping container to ensure consistency and will hand-deliver or ship samples as appropriate. If any errors are found on the COC after delivery/shipment, the paper copy of the COC maintained in Libby will be corrected by the sample coordinator with a single strikeout, initial, and date. The corrected copy will then be faxed to the analytical laboratory and the information updated in eLASTIC. A revised sample data file will then be transmitted (emailed) to Volpe by the CDM sample coordinator.

6.3.1.1 Sample Labeling and Identification

A unique alphanumeric code, or Index Identification (ID), will identify each sample collected during sampling events. The coding system will provide a tracking record to allow retrieval of information about a particular sample and to ensure that each sample is uniquely identified. Index IDs will be sequential and not be representative of any particular building or equipment. Index IDs will correlate with sample locations IDs, which will be identified on field sample data sheets (FSDSs) and in the field logbooks. The sample labeling scheme is as follows:

2R-XXXXX

Where:

2R identifies that a sample is collected in accordance with this SAP
XXXXX represents a 5-digit numeric code

Pre-printed adhesive Index ID labels will be signed out to sampling personnel by a member of the sample coordination team using an Index ID logbook. The labels are controlled to prevent duplication in assigning sample IDs. Index ID labels will be used in accordance with SOP 1-2, Sample Custody (Appendix A) for CDM subcontract laboratory samples. The labels will be affixed to both the sample cassette and sample bag for air samples, and both the inner and outer sample bags for soil samples.

6.3.1.2 Chain-of-Custody Requirements

Chain-of-custody procedures and sample shipment will follow the requirements stated in the site-specific SOP for eCOCs and CDM's SOP 1-2, Sample Custody, and SOP 2-1, Packaging and Shipping of Environmental Samples with modification (Appendix A). The COC record is employed as physical evidence of sample custody and control. This record system provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. A completed COC record is required to accompany each shipment of samples.

All samples will be relinquished to the sample coordinator by the sampler under strict custody. The sample coordinator will follow custody procedures to ensure proper sample custody between acceptance of samples from the samplers and shipment to the laboratory or CDM Close Support Facility.

6.3.1.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with SOP 2-1, Packaging and Shipping of Environmental Samples (Appendix A) for samples sent to a CDM subcontract laboratory, with modification. Custody seals will be placed on each sample and on at least two sides of the shipping container, if applicable. All samples will be picked up by a courier, delivered to the laboratories, or shipped by a delivery service to the designated laboratories, as necessary.

The following modifications to SOP 2-1 have been reviewed and approved for samples being analyzed for asbestos:

- **Section 1.4, Required Equipment** - Vermiculite (or other absorbent material), bubble wrap, or ice will not be used for packaging or shipping samples.
- **Section 1.5, Procedures** - No vermiculite or other absorbent material will be used to pack the samples. No ice will be used.

6.3.1.4 Field Logbook and Records

Field logbooks will be maintained in accordance with SOP 4-1, Logbook Content and Control (Appendix A). The log is an accounting of activities at the site and will duly note problems or deviations from the governing plans and observations relating to the sampling and analysis program. The field team leader will maintain the logbook(s) and will send copies of the field logbook on a weekly basis to the CDM PM in Denver for review and filing in the project files.

6.3.2 Laboratory Custody Procedures and Documentation

Laboratory custody procedures are provided in the laboratories' QA management plan for all laboratories. Upon receipt at the onsite laboratories, each sample shipment will be inspected to assess the condition of the shipping cooler and the individual samples. The enclosed COC records will be cross-referenced with all of the samples in the shipment. These records will be signed by the laboratory sample custodian and copies provided to CDM will be placed in the project files. The sample custodian will continue the COC record process by using the COC records number on each sample on receipt.

6.3.3 Corrections to and Deviations from Documentation

Documentation modification requirements for field logbook entries are described in SOP 4-1, Field Logbook Content and Control (Appendix A). For the logbooks, FSFS, and COCs, a single strikeout, initialed and dated, is required for documentation changes. The correct information should be entered in close proximity to the erroneous entry.

All deviations from the guiding documents will be recorded in the field logbook. Any major deviations will be documented via an approved Request for Modification form. Blank Request for Modification forms documenting changes to field plans and laboratory procedures, respectively, are provided in Appendix D. The EPA RPM will be notified of any major changes or deviations.

6.4 Analytical Methods Requirements

The laboratory QA program and analytical methods are addressed below.

6.4.1 Laboratory Quality Assurance Program

Samples collected during this project will be analyzed in accordance with standard EPA and/or nationally recognized analytical procedures. The analytical laboratories must be NVLAP (National Voluntary Laboratory Accreditation Program) certified and must follow the NVLAP QA program requirements. In addition, the laboratories performing analyses must follow all project-specific analytical and QA/QC modifications and must continue to participate in the project-specific analysis of performance evaluation samples, inter-laboratory samples, same and different analyst recounts, verified analyses, and laboratory duplicates at the project-specified frequencies.

6.4.2 Methods

The methods to be used for analysis are described in Section 5.4.2.4. The following asbestos analytical methods are provided in Appendix C:

- PCM (NIOSH 7400 Issue 2), for personal breathing zone air sample analysis

- TEM AHERA (40CFR Part 763 Subpart E) with modification, for stationary and final clearance air sample analysis, and positive identification of asbestos fibers as a supplement to NIOSH 7400

- PLM (NIOSH 9002 Issue 2), for soil confirmation samples

6.5 Quality Control Requirements

Field and internal office QC are discussed below.

6.5.1 Field Quality Control Samples

Field QC samples will consist of lot and field blanks for air sampling. The frequency of collection and analysis requested for lot and field blanks are discussed in detail in Section 3.2, Quality Assurance and Quality Control Samples. No other field quality control samples are required to be collected under this SAP.

6.5.2 Internal Quality Control Checks

Internal QC checks will be conducted throughout the project to evaluate the performance of the project team during data generation. All internal QC will be conducted in accordance with the applicable procedures listed below:

- All project deliverables will receive technical and QA reviews prior to being issued to EPA in any form.

- Completed review forms will be maintained in the project files.

- Corrective action of any deficiencies is the responsibility of the PM, with assistance from the QA staff, if necessary.

6.5.3 Quality Control Checks

Internal QC checks will be conducted throughout the project to evaluate the performance of the project team during data generation. All internal QC checks will be conducted in accordance with the applicable procedures listed below:

- All project deliverables will receive technical and QA reviews prior to being issued to EPA in any form in accordance with CDM's *Quality Assurance Manual*, Revision 10 (CDM 2002c).

- Completed QC Control review forms, which document technical and QA reviews of project deliverables, will be maintained in the project files.

- Field and office audits will each be performed at least once per 12-month period, or more frequently, if requested by the Volpe project manager.

- Field and office assessments may be performed as spot checks, at a frequency determined by the CDM QA Director.

- Corrective action of any deficiencies is the responsibility of the PM, with assistance from the QA staff, if necessary.

In addition to internal QC checks, Volpe or EPA may, at any time, perform independent audits or assessments of work practices, including field, office, or laboratory checks.

6.6 Equipment Maintenance Procedures

All field and laboratory equipment will be maintained in accordance with the manufacturers' maintenance and operating procedures. All maintenance activities will be documented in a logbook. For the field activities, a description of maintenance performed will appear in the field logbook on the date/time that it occurred. See Section 6.7.2 for details on record keeping for maintenance at the analytical laboratories.

6.7 Instrument Calibration Procedures and Frequency

Calibration of field and laboratory instruments is addressed in the following subsections.

6.7.1 Field Instruments

The only field measurements collected during this inspection are volume estimations. Since these do not require field instruments, no calibration or maintenance is required.

6.7.2 Laboratory Instruments

Calibration of laboratory instruments will be based on written procedures approved by laboratory management and included in the laboratory's QA manual. Instruments and equipment will be initially calibrated and continuously calibrated at required intervals as specified by either the manufacturer or more updated requirements (e.g., methodology requirements). Calibration standards used as reference standards will be traceable to EPA, National Institute of Standards and Technology, or another nationally recognized reference standard source.

Records of initial calibration, continuing calibration, repair, and/or replacement of laboratory equipment will be filed and maintained by the laboratories. Calibration records will be filed and maintained at the laboratories' location where the work is performed and may be required to be included in data reporting packages.

6.8 Acceptance Requirements for Supplies

Prior to acceptance, all supplies and consumables will be inspected by the site coordinator to ensure that they are in satisfactory condition and free of defects.

6.9 Nondirect Measurement Data Acquisition Requirements

Nondirect measurement data include information from previous sampling events. The acceptance criteria for such data include a review by someone other than the author. Any measurement data included in information from the above sources (i.e., previous sampling event) will determine further action at the Site only to the extent that those data can be verified by project staff.

6.10 Data Management

The laboratories will submit hard copy sample data packages to the CDM laboratory coordinator, and electronic data deliverables (EDDs) to Volpe, the laboratory coordinator, and the sample coordinator. The onsite laboratory will also report sample results via facsimile to the sample coordinator. The CDM laboratory coordinator will provide hard copy sample data package deliverables to Volpe as they are received and reviewed for completeness.

Section 7
Assessment and Oversight

Assessments and oversight reports to management are necessary to ensure that procedures are followed as required and that deviations from procedures are documented. These reports also serve to keep management current on field activities. Assessment and oversight reports are discussed below.

7.1 Assessments and Response Actions

Assessments and corresponding response actions are discussed below.

7.1.1 Assessments

Performance assessments are quantitative checks on the quality of a measurement system and are appropriate to analytical work. Performance assessments for the laboratories may be accomplished by submitting reference material as blind reference (or performance evaluation) samples. These assessment samples are samples with known concentrations that are submitted to the laboratories without informing the laboratories of the known concentration. Samples will be provided to the laboratories for performance assessment upon request from the EPA RPM or Volpe PM. Laboratory audits may also be conducted upon request from the EPA RPM or Volpe PM.

System assessments are qualitative reviews of different aspects of project work to check on the use of appropriate QC measures and the functioning of the QA system. Any determination or changes for project assessments will be performed under the direction of the QA manager, who reports directly to the CDM president. Quality Procedure 6.2, as defined in the CDM RAC Region VIII QMP (CDM 2003a), defines CDM's corporate assessments, procedures, and requirements. Due to the amount of sampling and the duration of the project, both a field audit and an office audit are scheduled for the Site annually.

7.1.2 Response Actions

Response actions will be implemented on a case-by-case basis to correct quality problems. Minor response actions taken in the field to immediately correct a quality problem will be documented in the applicable field logbook and a verbal report will be provided to the CDM PM. For verbal reports, the CDM PM will complete a communication log to document that response actions were relayed to him. Major response actions taken in the field will be approved by the CDM PM and the EPA RPM and Volpe PM prior to implementation of the change. Major response actions are those that may affect the quality or objective of the inspection. Quality problems that cannot be corrected quickly through routine procedures require implementation of a corrective action request (CAR) form.

All formal response actions will be submitted to either CDM's or regional QA coordinator for review and issuance. CDM's PM or local QA coordinator will notify the QA manager when quality problems arise that may require a formal response action. CAR forms will be completed according to Quality Procedure 8.1 of the CDM RAC Region VIII QMP (CDM 2003a).

7.2 Reports to Management

QA reports will be provided to management whenever quality problems are encountered. Field staff will note any quality problems on field data sheets. CDM's PM will inform the project QA coordinator upon encountering quality issues that cannot be immediately corrected. Weekly reports and change request forms are not required for this work assignment. Monthly QA reports will be submitted to CDM's QA manager by the project QA coordinator.

Topics to be summarized regularly may include but not be limited to:

- Document technical and QA reviews that have been conducted
- Activities and general program status
- Project meetings
- Corrective action activities
- Any unresolved problem
- Any significant QA/QC problems not included above

Section 8
Data Validation and Usability

Laboratory results will be reviewed for compliance with project objectives. Data validation and evaluation are discussed in Sections 8.1 and 8.2, respectively.

8.1 Data Review, Validation, and Verification Requirements

CDM and/or EPA will validate data submitted by analytical laboratories. Data validation will be performed according to the EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 2002), with method specific requirements superseding the NFG guidelines. Also, in accordance with the technical memorandum regarding data validation (CDM 2002c), the qualifications will include reason codes and a bias, if discernible. If validation is requested, an SOP for the method-specific validation process will be prepared. In general, data validation consists of examining the sample data package(s) against pre-determined standardized requirements. The validator may examine, as appropriate, the reported results, QC summaries, case narratives, COC information, raw data, LCS/LCSDs, MS/MSDs, initial and continuing instrument calibration, and other reported information to determine the accuracy and completeness of the data package. During this process, the validator will verify that the analytical methodologies were followed and QC requirements were met. The validator may recalculate selected analytical results to verify the accuracy of the reported information. Analytical results will then be qualified as necessary.

Data verification includes checking that results have been transferred correctly from laboratory data printouts to the laboratory report and to the EDD.

8.2 Reconciliation with Data Quality Objectives

Once data has been generated, CDM evaluates data to determine if DQOs were achieved. This achievement will be discussed in the measurement report, including the data and any deviations to this SAP. Additionally, a section in the measurement report will present the data quality assessment (DQA) evaluation. The DQA will synthesize the data reviews described in Section 8.1 and provide information about any overall biases introduced into the data due to either field or analytical activities. All QC sample results will be maintained in the same database along with the investigative sample results.

Section 9
References

CDM. 2003a. RAC Region VIII Quality Management Plan. January.

_____. 2003b. Modification to Laboratory Activities. June.

_____. 2002a. Final Sampling and Analysis Plan for the Remedial Inspection of Contaminant Screening Study. April.

_____. 2002b. Technical Standard Operating Procedures Manual. Revision 16. December.

_____. 2002c. Quality Assurance Manual, Revision 10. February.

_____. 2002d. Final Memorandum Regarding Data Validation and Laboratory Review, Meeting Summary and Modification to CDM's Validation/Evaluation Procedures. November.

_____. 2000. RAC Region VIII Work Plan, Revision 4B. November.

EPA. 2002. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, Final. July.

_____. 2001. EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, QA/R-5, Final.

_____. 2000. Guidance for the Data Quality Objectives Process, EPA QA/G-4, Final. September.

_____. 1994. Test Methods for Evaluating Solid Waste, Laboratory Manual. 3rd Edition. September with revisions.

Appendix A
CDM Standard Operating Procedures
and
Project-Specific Procedures

Confirmation Soil Sampling Procedures

Sample Collection

All soil samples will be collected in accordance with CDM Technical SOP 1-3 Surface Soil Sampling and SOP 1-4 Subsurface Soil Sampling with the following modifications:

Section 2.2, Discussion - Sample depth for surface soil will generally be 0 to 2 inches from the current ground surface. Composite samples will be composed of nearly equal portions of soil from five randomly discrete locations within a selected area. The field composite sample will be obtained from an aliquot of a total volume of homogenized soil.

Section 4.0, Required Equipment - Neither ice bags nor blue ice will be used. Powder-free nitrile gloves will be used for sample collection. No pans, trays, or bowls are necessary, since samples will be placed directly into zipper-top bags. Since the sampling is for asbestos, rather than metals or organic compounds, the use of stainless steel or Teflon-lined sampling instruments is determined not to be necessary. The sampling devise may be a garden bulb planter, trowel, or other similar sampling device.

Section 5.2.3, Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analysis - One-gallon zipper-top bags will be used as sample containers. The one-gallon bags will be filled at least half full. Sampling information will be written directly on the bags using a permanent marker. Sampling instruments do not need to be constructed of stainless steel or Teflon lined. Trays and bowls will not be used, as samples will be placed directly into zipper-top bags. Field homogenization will be performed by manipulating the sampled material inside the zipper-locked bag. All samples will be double bagged for hand delivery to the onsite laboratory.

Sample Documentation

Confirmation sampling activities will be documented in the applicable field logbooks and on field sample data sheets (FSDS). The logbooks are to be maintained by the field team in accordance with CDM SOP 4-1 Field Logbook Content and Control. The field team leader will be responsible for maintenance and document control of the field logbook.

Sample Custody, Packaging, and Shipping

This section details the sample custody and the classifying, identifying, labeling, packaging, and transporting of soil samples collected during confirmation sampling. Procedures will be in accordance with CDM SOPs 1-2 Sample Custody as described below.

Sample classification is necessary to ensure the protection of personnel involved in the shipment of samples, and to maintain the integrity of each sample. Samples obtained at uncontrolled hazardous waste sites are classified as either environmental or hazardous samples. All confirmation samples collected will be classified as environmental.

To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, chain-of-custody (COC) records will be used. The COC record is employed as physical evidence of sample custody and control, and provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. COC procedures will follow the requirements set forth in CDM SOP 1-2 Sample Custody with the following modifications:

Section 5.2, Sample Labels and Tags - Rather than using labels or tags, samples will be identified by writing sample index information directly on the one-gallon zipper-top bags using permanent markers.

Confirmation samples collected by the CDM oversight representative will be relinquished to the project sample coordinator. The sample coordinator will hand delivered the samples, under chain of custody, to the onsite laboratory for analysis.

Equipment Decontamination

Equipment used to collect, handle, or measure soil samples will be decontaminated in accordance with CDM SOP 4-5 Field Equipment Decontamination at Nonradioactive Sites, with the following modifications:

Section 5.0, Procedures - Decontamination water will not be captured and will be discharged to the ground at the site.

Section 5.3, Sampling Equipment Decontamination - ASTM Type II deionized (DI) water will not be used. Rather, locally available DI water will be used. Decontamination water will be discharged to the ground at the site.

Section 5.6, Waste Disposal - Decontamination water will not be captured and will not be packaged, labeled, or stored as investigation-derived waste.

The decontamination procedure for non-disposable equipment consists of a tap water and alconox wash with brush scrubbing, followed by a tap water rinse, and final DI water rinse. The equipment will then be allowed to air-dry before being wrapped in clean plastic or aluminum foil. All equipment will be decontaminated before coming into contact with any sample. Rinse water will be discharged to the ground at the site. Any deviations from the decontamination procedures will be recorded in the appropriate field logbook.

SURFACE SOIL SAMPLING	SOP 1-3 Revision: 4 Date: June 20, 2001 Page 1 of 12

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Technical Review: Brian Jenks

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Approved: [signature] 6/20/01

Signature/Date

Issued: Rosemary J. Gustin 6/20/01

Signature/Date

1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to define the techniques and the requirements for collecting surface soil samples.

2.0 BACKGROUND

Surface soils are generally defined as the soils extending from ground surface to approximately 1 foot below ground surface (bgs). Surface soil samples are frequently collected from 0 to 6 inches bgs. The techniques and protocol described herein may be used to collect other surface media, including sediment and sludge.

2.1 Definitions

Surface Soil - The soil that exists down from the surface approximately one foot (30 centimeters). Depending on application, the soil interval to be sampled will vary.

Grab Sample - A discrete portion or aliquot taken from a specific location at a given point in time.

Composite - Two or more sub-samples taken from a specific media and site at a specific point in time. The sub-samples are collected and mixed, then a single average sample is taken from the mixture.

Spoon/Scoop - A small stainless steel or Teflon® utensil approximately 6 inches in length with a stem-like handle.

Trowel - A small stainless steel or Teflon® shovel approximately 6 to 8 inches in length with a slight (approximately 140°) curve across. The trowel has a stem-like handle (for hand operation). Samples are collected with a spooning action.

2.2 Discussion

Surface soil samples are collected to determine the type(s) and level(s) of contamination and are often important to risk assessment. These samples may be collected as part of an investigative plan, site-specific sampling plan, and/or as a screen for "hot spots," which may require more extensive sampling.

Sediment(s) and sludge(s) that have been exposed by evaporation, stream rerouting, or any other means are collected by the same methods as those for surface soil(s). Typically, the top 1 to 2 centimeters (cm) of material, including vegetation, are carefully removed before collection of the sample.

Surface soil and exposed sediment or sludge are collected using stainless steel and/or Teflon®-lined trowels or scoops.

2.3 Associated Procedures

- CDM Federal SOP 1-2, Sample Custody
- CDM Federal SOP 2-1, Packaging and Shipping of Environmental Samples
- CDM Federal SOP 4-1, Field Logbook Content and Control
- CDM Federal SOP 4-5, Field Equipment Decontamination at Non-radioactive Sites

3.0 RESPONSIBILITIES

Site Manager - The site manager is responsible for ensuring that sampling efforts are conducted in accordance with this procedure and any other SOPs pertaining to specific media sampling.

Field Team Leader - The field team leader is responsible for ensuring that field personnel collect surface soil samples in accordance with this and other relevant procedures.

4.0 REQUIRED EQUIPMENT

- Insulated cooler and waterproof sealing tape
- Ice bags or "blue ice"
- Latex or appropriate gloves
- Plastic zip-top bags
- Personal protective clothing and equipment
- Stainless steel and/or Teflon®-lined spatulas and pans, trays, or bowls
- Stainless steel and/or Teflon®-lined trowels or spoons (or equipment as specified in the site-specific plans)
- Plastic sheeting
- Project plans (work plan/health and safety plan)
- Appropriate sample containers
- Field logbook
- Indelible ink pen and/or marker
- Sample chain-of-custody forms
- Custody seals
- Decontamination supplies

Additional equipment is discussed in Section 5.2.2, VOC Field Sampling/Preservation Methods.

5.0 PROCEDURES

5.1 Preparation

The following steps must be followed when preparing for sample collection:

1. Don the appropriate personal protective clothing as dictated by the site-specific health and safety plan.

2. Locate sampling location(s) in accordance with project documents (e.g., work plan) and document pertinent information in the appropriate field logbook.

3. Processes for verifying depth of sampling must be specified in the site-specific plans.

4. Place clean plastic sheeting on a flat, level surface near the sampling area, if possible, and place equipment to be used on the plastic; place the insulated cooler(s) on separate plastic sheeting. Cover all equipment and supplies with clean plastic sheeting when not in use.

5. A clean, decontaminated trowel, scoop, or spoon will be used for each sample collected. Other equipment may be used (e.g., shovels) if constructed of stainless steel.

5.2 Collection

The following general steps must be followed when collecting surface soil samples:

1. Surface soil samples are normally collected from the least contaminated to the most-contaminated areas.

2. Document the sampling events, recording the information in the designated field logbook. Document any and all deviations from SOPs in the field logbook and include rationale for changes. See CDM Federal SOP 4-1.

3. Carefully remove stones, vegetation, snow, etc. from the ground surface in the immediate vicinity of the sampling location.

4. First collect required sample aliquot for volatile analyses as well as any other samples that would be degraded by aeration. Follow with collection of samples for other analyses.

5. Decontaminate sampling equipment between locations. See CDM Federal SOP 4-5.

5.2.1 Method for Collecting Samples for Volatile Organic Compound (VOC) Analysis

The requirements for collecting grab samples of surface soil for VOCs or other samples degraded by aeration are as follows:

1. VOC samples shall be collected with the least disturbance possible.

2. VOC samples shall be collected as grab samples; however, the method of collection will vary from site to site, based on data quality objectives and the degree of known or suspected contamination.

3. Complete sample label by filling in the appropriate information and securing the label to the container. Cover the sample label with a piece of clear tape.

4. Use a clean stainless steel or Teflon®-lined trowel or spoon (or tube) to collect sufficient material in one grab to fill the sample containers.

5. With the aid of a clean stainless steel spatula, quickly fill the sample containers directly from the sampling device, removing stones, twigs, grass, etc., from the sample. Fill the containers as full and compact as possible to minimize headspace.

6. Immediately secure the Teflon®-lined cap(s) on the sample container(s).

7. Wipe the containers with a clean Kimwipe or paper towel to remove any residual soil from the exterior of the container.

8. Place the containers in individual zip-top plastic bag(s) and seal the bag(s).

9. Pack all samples as required. Include properly completed documentation, and affix signed and dated custody seals to the cooler lid.

NOTE: A trip blank should be included with sample coolers containing VOC samples. QA sample requirements vary from project to project. Consult the project-specific work plan for requirements.

5.2.2 Field Sampling/Preservation Methods

The following four sections contain SW 846 methods for sampling and field preservation. These methods include EN CORE™ Sampler Method for low-level detection limits, EN CORE™ Sampler Method for high level/detection limits/screening, acid preservation, and methanol preservation. These methods are very detailed and contain equipment requirements at the beginning of each section.

NOTE: Some variations from these methods may be required depending on the contracted analytical laboratory, such as sample volume.

5.2.2.1 EN CORE™ SAMPLER COLLECTION FOR LOW LEVEL ANALYSES (≥1 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for low-level analysis:

- Three 5-g samplers

NOTE: The sample volume requirements are general requirements. Actual sample volumes, sizes, and quantities may vary depending on client or laboratory requirements.

- One 4-ounce widemouth glass jar or applicable container for moisture analysis
- One T-handle
- Paper towels

EN CORE™ Sampling Steps for Low Level Analysis

1. Remove sampler and cap from package and attach T-handle to sampler body.

2. Quickly push the sampler into a freshly exposed surface of soil until the O-ring is visible within the hole on the side of the T-handle. If the O-ring is not visible within this window, then the sampler is not full.

3. Extract the sampler and wipe the sampler head with a paper towel so that the cap can be tightly attached.

4. Push cap on with a twisting motion to secure to the sampler body.

5. Rotate the sampler stem counterclockwise until stem locks in place to retain sample within the sampler body.

6. Fill out sample label and attach to sampler.

7. Repeat procedure for the other two samplers.

8. Collect moisture sample in 4-ounce widemouth jar using a clean stainless steel spoon or trowel.

9. Store samplers at 4° Celsius. Samples must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

NOTE: Verify state requirements for extraction/holding times.

5.2.2.2 ACID PRESERVATION SAMPLING FOR LOW LEVEL ANALYSES (≤1 UG/KG)

Acid Preservation Sampling Equipment Requirements

The following equipment and supplies are required if field acid preservation is required:

- One 40mL VOA vial with acid preservation (for field testing of soil pH)
- Two pre-weighed 40mL VOA vials with acid preservative and stir bar (for lab analysis)
- Two pre-weighed 40mL VOA vials with water and stir bar (in case samples cannot be pre-preserved)
- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (for screening sample and/or high level analysis)
- One 4-oz widemouth glass jar or applicable container for moisture analysis
- One 2-oz jar with acid preservative (in case additional acid is needed due to high soil pH)
- One appropriately sized scoop capable of delivering 1g of solid sodium bisulfate
- pH paper
- Weighing scale capable of reading to 0.01g
- Set of balance weights used in daily balance calibration
- Gloves for working with pre-weighed sample vials
- Paper towels
- Sodium bisulfate acid ($NaHS0_4$)
- A cutoff plastic syringe or other coring device capable of collecting sufficient sample volume (5g)

Testing Effervescing Capacity of Soils

Soils must be tested with acid to determine the amount of effervescing that will occur when preserved with acid. Effervescing will drive off VOCs as well as create a high pressure in a sealed vial that could result in the explosion of the sample container. The following steps provide information on the effervescing capacity of the soil.

1. Place approximately 5g of soil into a vial that contains acid preservative and no stir bar.

2. Do not cap this vial as it may EXPLODE upon interaction with the soil.

3. Observe the sample for gas formation (due to carbonates in the soil).

4. If vigorous or sustained gas emissions are observed, then acid preservation is not acceptable to preserve the sample.
    - In this case the samples need to be collected in the VOA vials with only water and a stir bar. The vials with acid preservative CANNOT be used.

5. If a small amount or no gas formation occurs, then acid preservation is acceptable to preserve the sample. Keep this testing vial for use in the buffering test detailed below.

    - In this case the samples need to be collected in the VOA vials with the acid preservative and a stir bar.

<u>Testing Buffering Capacity of Soils</u>

The soils must be tested to determine the quantity of acid that is required to achieve a pH reading of ≤ 2 standard units (STUs). The following steps will assist in determining this quantity.

1. If acid preservation is acceptable for sampling soils, then the sample vial that was used to test the effervescing capacity of the soils can be used to test the buffering capacity.

2. Cap the vial that contains 5g of soil, acid preservative, and no stir bar from Step 1 in the effervescing test.

3. Shake the vial gently to homogenize the contents.

4. Open the vial and check the pH of the acid solution with pH paper.

    - If the pH paper reads below 2, then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar. Since the pH was below 2, it is not necessary to add additional acid to the vials.

    - If the pH paper reads above 2, then additional acid needs to be added to the sample vial.

5. Use the jar with the solid sodium bisulfate acid and add another 1g of acid to the sample.

6. Cap the vial and shake thoroughly again.

7. Repeat Step 4.

    - If the pH paper reads below 2, then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar and one extra gram of acid.

    - Make a note of the extra gram of acid needed so the same amount of acid can be added to the vials the lab will analyze.

    - If the pH paper reads above 2, repeat Steps 5 through 7 until the sample pH ≤2 STUs.

Now that the soil chemistry has been determined, the actual sampling can occur. The procedure stated below assumes the correct vials are used based on the guidance discussed.

Sample Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.

2. Add more acid if necessary (based on the buffering capacity testing discussed in the previous section).

3. Quickly collect a 5g sample using a cut off plastic syringe or other coring device designed to deliver 5g of soil from a freshly exposed surface of soil.

4. Carefully wipe exterior of sample collection device with a clean paper towel.

5. Quickly transfer the sample to the appropriate VOA vial, use caution when extruding the sample to prevent splashing of the acid in the vial.

6. Remove any soil from the threads of the sample vial using a clean paper towel.

7. Cap vial and weigh the jar to the nearest 0.01g.

8. Record exact weight on sample label.

9. Repeat sampling procedure for the duplicate VOA vial.

10. Weigh the vial containing methanol preservative in it to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation below.

11. Take the empty jar or the jar that contains the methanol preservative.

12. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil. The 25g or 5g size is dependent on who is doing the sampling and requirements specified by the analytical laboratory.

13. Carefully wipe the exterior of the collection device with a clean paper towel.

14. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial.

15. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.

16. Remove any soil from the threads of the sample vial using a clean paper towel and cap the jar.

17. Weigh the jar with sample to the nearest 0.01g and record the weight on the sample label.

18. Collect dry weight sample using a clean stainless steel spoon or trowel.

19. Store samples at 4° Celsius.

20. Ship sample containers to the analytical laboratory with plenty of ice in accordance with Department of Transportation (DOT) regulations (CORROSIVE. FLAMMABLE LIQUID. POISON).

5.2.2.3 EN CORE™ SAMPLER COLLECTION FOR HIGH LEVEL ANALYSES (≥200 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for high-level analysis.

- One 25-g sampler or one 5-g sampler

NOTE: The volume requirements specified are general requirements. Actual sample volumes, container sizes, and quantities may vary depending on client or laboratory requirements.

- One 4-oz widemouth glass jar of applicable container specified for moisture analysis
- One T-handle
- Paper towels

EN CORE™ Sampling Steps for High Level Analysis

1. Remove sample and cap from package and attach T-handle to sampler body.

2. Quickly push the sampler into freshly exposed surface of soil until the O-ring is visible within the hole/window on the side of the T-handle. If the O-ring is not visible within the window/hole, then the sampler is not full.

3. Use a clean paper towel to quickly wipe the sampler head so that the cap can be tightly attached.

4. Push cap on with a twisting motion to secure to the sampler body.

5. Fill out sample label and attach to sampler.

6. Rotate sampler stem counterclockwise until the stemlocks in place to retain the sample within the sampler body.

7. Collect moisture sample in 4-oz widemouth glass jar or designated container using a clean stainless steel spoon or trowel.

8. Store samplers at 4° Celsius. Samples must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

NOTE: Verify state requirements for extraction/holding times.

5.2.2.4 METHANOL PRESERVATION SAMPLING FOR HIGH LEVEL ANALYSES (≥200 UG/KG)

Methanol Preservation Sampling Equipment Requirements

- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (laboratory grade)
- One dry weight cup
- Weighing balance that accurately weighs to 0.01g
- Set of balance weights used in daily balance calibration
- Latex gloves
- Paper towels
- Cutoff plastic syringe or other coring device to deliver 5g or 25g of soil

Sampling Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.

2. Weigh the vial containing methanol preservative in it to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation/ collection below.

3. Take the empty jar or the jar that contains the methanol preservative.

4. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil.

5. Carefully wipe the exterior of the collection device with a clean paper towel.

6. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial. Again, the type of jar used is dependent on who is doing the laboratory analysis.

7. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.

8. Remove any soil from the exterior of the vial using a clean paper towel and cap the sample jar.

9. Weigh the jar with the soil in it to the nearest 0.01g and record the weight on the sample label.

10. Collect dry weight sample using a clean stainless steel spoon or trowel.

11. Store samples at 4° Celsius.

12. Ship sample containers with plenty of ice to the analytical laboratory in accordance with DOT regulations (CORROSIVE. FLAMMABLE LIQUID. POISON).

5.2.3 Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analysis

The requirements for collecting samples of surface soil for nonvolatile organic or inorganic analyses are as follows:

1. Label each sample container with the appropriate information. Secure the label by covering it with a piece of clear tape.

2. Use a decontaminated stainless steel or Teflon®-lined trowel or spoon to obtain sufficient sample from the required interval and sub-sampling points, if necessary, to fill the specified sample containers.

3. Empty the contents of each fill of the sampling device directly into a clean stainless steel or Teflon®-lined tray or bowl.

4. Homogenize the sample by mixing with a spoon, spatula, or trowel.

5. Use the spoon, spatula, or trowel to distribute the uniform mixture into the labeled sample containers. Fill organic sample containers first, then inorganics.

6. Secure the appropriate cap on each container immediately after filling it.

7. Wipe the sample containers with a clean Kimwipe or paper towel to remove any residual soil.

8. Place sample containers in individual zip-top plastic bags and seal the bags.

9. Pack all samples as required. Include properly completed documentation, and affix custody seals to the cooler lid.

10. Decontaminate sampling equipment according to CDM Federal SOP 4-5.

6.0 RESTRICTIONS/LIMITATIONS

When grab sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration, it is necessary to minimize sample disturbance and, hence, analyze loss. The representativeness of this sample is difficult to determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

7.0 REFERENCES

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Quality Control Requirements For Field Methods*, DOE/HWP-69/R1, July 1990 or current revision.

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Standard Operating Procedures For Site Characterizations*, DOE/HWP-100/R2, September 1996 or current revision.

U.S. Environmental Protection Agency, *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987 or current revision.

U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste*, Physical/Chemical Methods (SW-846), Third Edition, November 1986, (as amended by Update III, June 1997). Method 5035: Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples.

SUBSURFACE SOIL SAMPLING

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1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to define the techniques and requirements for collecting soil samples from the unconsolidated zone. Techniques include use of hand augers, Shelby tubes, continuous core samplers, and split-spoon samplers.

2.0 BACKGROUND

2.1 Definitions

Unconsolidated Zone - The layer of soil above bedrock that exists in a relatively loose state.

Hand Auger - A stainless steel cylinder (bucket) approximately 3 to 4 inches in diameter and 1 foot in length, open at both ends with the bottom edge designed to twist into the soil and cut out a soil core. The bucket collects the soil sample. The auger has a T-shaped handle (for hand operation) attached to the top of the bucket by extendable stainless steel rod(s).

Shelby Tube - A cylindrical sampling device, generally made of steel, which is driven into the subsurface soil through the hollow-stem auger. The tube, once retrieved, may be capped and the undisturbed soil sample extruded in the laboratory prior to analysis.

Split-Spoon - A cylindrical sampling device, generally made of carbon steel, which fits into a hollow stem auger. The spoon is hinged lengthwise, which allows the sample to be retrieved by opening ("splitting") the spoon.

Subsurface Soil - The soil which exists deeper than approximately 1 foot (30 centimeters) from the surface but above bedrock or any other consolidated material.

Grab Sample - A discrete portion or aliquot taken from a specific location at a given point in time.

Liner - A cylindrical sampling device, generally made of brass, stainless steel, or Teflon® that is placed inside a split-spoon or hand auger bucket to collect undisturbed samples.

Composite Sample - Two or more sub-samples taken from a specific media and site at a specific point in time. The sub-samples are collected and mixed, then a single average sample is taken from the mixture.

Auger Flight - A steel section length attached to an auger to extend the auger as coring depth increases.

2.2 Discussion

Shallow subsurface soil samples (to depths between 6 inches and 10 feet) may be collected using hand augers. However, soil samples collected with a hand auger are commonly of poorer quality than those collected by split-spoon or Shelby tube samplers since the soil sample is disturbed in the augering process. Split-spoon and Shelby tube liners may be used to prevent loss of volatile organic compounds (VOCs). The size and construction material of sampling devices should be selected based on project and analytical objectives and defined in site-specific plans.

2.3 Associated Procedures

- CDM Federal SOP 1-2, Sample Custody
- CDM Federal SOP 2-1, Packaging and Shipping of Environmental Samples
- CDM Federal SOP 3-5, Lithologic Logging
- CDM Federal SOP 4-1, Field Logbook Content and Control
- CDM Federal SOP 4-5, Field Equipment Decontamination at Nonradioactive Sites

3.0 RESPONSIBILITIES

Site Manager - The site manager is responsible for ensuring that field personnel are trained in the use of this procedure and the required equipment, and for ensuring that subsurface soil samples are collected in accordance with this procedure and any other SOPs pertaining to specific media sampling.

Field Team Leader - The field team leader is responsible for ensuring that field personnel collect subsurface soil samples in accordance with this SOP and other relevant procedures.

4.0 REQUIRED EQUIPMENT

4.1 General

- Site-specific plans
- Field logbook
- Indelible black ink pens and markers
- Labels and appropriate forms/documentation for sample shipment
- Clear, waterproof tape
- Appropriate sample containers

- Insulated cooler(s) and waterproof sealing tape
- Ice bags or "blue ice"
- Latex or appropriate gloves
- Plastic zip-top bags
- Personal protective clothing and equipment
- Stainless steel and/or Teflon®-lined spatulas and pans, trays, or bowls
- Plastic sheeting

Additional equipment is discussed in Section 5.2.2 VOC Field Sampling/Preservation Methods.

4.2 Manual (Hand) Augering

- T-handle
- Hand auger: flighted-, bucket-, or tube-type auger as required by the site-specific plans
- Extension rods
- Wrench(es), pliers

4.3 Split-Spoon and Shelby Tube Sampling

- Drill rig equipped with a 140-lb drop hammer and sufficient hollow-stem augers to drill to the depths required by the site-specific plans.
- Sufficient numbers of split-spoon or Shelby tube samplers so that at least one is always decontaminated and available for sampling. Three split-spoon or Shelby tube samplers are generally the minimum necessary. (Shelby tubes are usually used only once.)
- Split-spoon liners (as appropriate).
- Wrench(es), hammer.

5.0 PROCEDURES

5.1 Preparation

1. Don the appropriate personal protective clothing as dictated by the site-specific health and safety plan.

2. Locate sampling location(s) in accordance with project documents (e.g., work plan) and document pertinent information in the appropriate field logbook. When possible, reference locations back to existing site features such as buildings, roads, intersections, etc..

3. Processes for verifying depth of sampling must be specified in the site-specific plans.

4. Clear away vegetation and debris from the surface at the boring location.

5. Prepare an area next to the sample collection location for laying out cuttings by placing plastic sheeting on the ground to cover the immediate area surrounding the borehole.

6. Set up a decontamination line, if decontamination is required in accordance with CDM Federal SOP 4-5.

5.2 Collection

The following general steps must be followed when collecting all subsurface soil samples:

1. VOC samples or samples degraded by aeration shall be collected first and with the least disturbance possible. These samples shall be collected as grab samples.

2. Sampling information shall be recorded in the field logbook and on any associated forms. Describe lithology, according to CDM Federal SOP 3-5, in the field logbook or on the lithologic log form.

3. Specific sampling devices to be used shall be identified in the site-specific plans and recorded in the field logbook.

4. Care must be taken to prevent cross-contamination and misidentification of samples.

5. Processes for verifying depth of sampling must be specified in the site-specific plans.

6. Sample bottles for VOC analysis should be filled completely to minimize headspace.

5.2.1 Manual (Hand) Augering

The following steps must be followed when collecting hand-augered samples:

1. Auger to the depth required for sampling. Place cuttings on plastic sheeting or as specified in the site-specific plans. If possible, lay out the cuttings in stratigraphic order.

2. Throughout the augering, make detailed notes concerning the geologic features of the soil or sediments in the field logbook.

3. Cease augering when the top of the specified sampling depth has been reached. If required, remove the auger from the hole and decontaminate the auger or use a fresh auger. Then obtain the sample.

4. Collect a grab sample for VOC analyses (or samples that may be degraded by aeration)

immediately and place in sample container. Sample bottles should be filled completely to minimize headspace.

5. Label the sample container with the appropriate information. Secure the label by covering it with a piece of clear tape.

6. Remaining sample should be homogenized for other analyses prior to placing samples in the appropriate containers. Label containers as required.

7. Wipe containers with a clean Kimwipe or paper towel to remove residual soil from the exterior of the container(s).

8. Place the containers in zip-top plastic bags and seal the bags. Pack samples in a cooler with ice.

9. Proceed with further sampling, as required by the site-specific plans.

10. When all sampling is complete, dispose of cuttings, plastic sheeting, etc., as specified in the site-specific plans.

11. Complete the field logbook entry and other appropriate forms, being sure to record all relevant information before leaving the site.

12. Properly package all samples for shipment and complete all necessary sample shipment documentation. Remand custody of samples to the appropriate personnel. See CDM Federal SOPs 1-2 and 2-1 or site-specific plans.

5.2.2 Field Sampling/Preservation Methods

The following four sections contain SW 846 Methods for sampling and field preservation. These methods include ENCORE ™ Sampler Method for low-level detection limits, ENCORE ™ Sampler Method for high-level limits/screening, acid preservation, and methanol preservation. These methods may be used if required by the EPA Region, client, or governing sample plan. These methods are very detailed and contain equipment requirements at the beginning of each section.

Note: Some variations from these methods may be required depending on the contracted analytical laboratory, such as sample volume.

5.2.2.1 EN CORE™ SAMPLER COLLECTION FOR LOW LEVEL ANALYSES (≥1 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for low level analysis:

- Three 5g samplers

NOTE: The sample volume requirements specified are general requirements. Actual sample volume and/or container sizes, may vary depending on client or laboratory requirements.

- One dry weight cup
- One T-handle
- Paper towels

EN CORE™ Sampling Steps for Low Level Analysis

1. Remove sampler and cap from package and attach T-handle to sampler body.

2. Quickly push the sampler into a freshly exposed surface of soil until the sampler is full.

3. Extract sampler and wipe the sampler head with a paper towel so that the cap can be tightly attached.

4. Push cap on with a twisting motion to secure.

5. Fill out sample label and attach to sampler.

6. Repeat procedure for the other two samplers.

7. Collect dry weight sample (60 ml).

8. Store samplers at 4 degrees (°) Celsius.

Ship sample containers with plenty of ice to the laboratory within 40 hours of collection.

NOTE: Verify state requirements for extraction/holding times.

5.2.2.2 ACID PRESERVATION SAMPLING FOR LOW LEVEL ANALYSES (≥1 UG/KG)

Acid Preservation Sampling Equipment Requirements

The following equipment and supplies are required if field preservation is required:

- One 40mL VOA vial with acid preservation (for field testing of soil pH). Two pre-weighed 40mL VOA vials with acid preservative and stir bar (for lab analysis).
- Two pre-weighed 40mL VOA vials with water and stir bar (in case sample effervesces).
- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (for screening sample and/or high level analysis).
- One dry weight cup.
- One 2oz jar with acid preservative (in case additional acid is needed due to high soil pH).
- One scoop capable to deliver about 1g of solid sodium bisulfate.
- pH paper.
- Weighing balance that weighs to 0.01g (with an accuracy $\pm$0.1g).
- Set of balance weights used in daily balance calibration.
- Gloves for working with pre-weighed sample vials.
- Paper towels.
- Sodium bisulfate acid ($NaHSO_4$) acid.
- A cutoff plastic syringe or other coring device to deliver 5g or 25g of soil.

Testing Effervescing Capacity of Soils

Soils must be tested with acid to determine the amount of effervescing that will occur when preserved with acid. Effervescing will drive off VOCs as well as create a very high pressure in a sealed vial which could explode. The following steps will provide information on the effervescing capacity of the soil.

1. Place approximately 5g of soil into a vial that contains acid preservative and no stir bar.

2. Do not cap this vial as it may EXPLODE upon interaction with the soil.

3. Observe the sample for gas evolution (due to carbonates in the soil).

4. If vigorous or sustained gas evolution occurs, then acid preservation is not acceptable to preserve the sample.
    - In this case the samples need to be collected in the VOA vials with only water and a stir bar. The vials with acid preservative CANNOT be used.

5. If a small amount or no gas evolution occurs, then acid preservation is acceptable to preserve the sample. Keep this testing vial for use in the buffering test detailed below.

- In this case the samples need to be collected in the VOA vials with the acid preservative and a stir bar.

Testing Buffering Capacity of Soils

The soils must be tested to determine the quantity of acid that is required to reach a less than 2 pH reading. The following steps will assist in determining this quantity.

1. If acid preservation is acceptable for sampling soils, then the sample vial that was used in the effervescing testing can be used here for the buffering testing.

2. Cap the vial that contains approximately 5g of soil, acid preservative, and no stir bar from Step 1 in the effervescing testing.

3. Shake the vial gently to attempt to make a homogenous solution.

4. When done, open the vial and check the pH of the acid solution with pH paper.

    - If the pH paper reads below 2, then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar. Since the pH was below 2, it is not necessary to add additional acid to the vials.

    - If the pH paper reads above 2, then additional acid needs to be added to the sample vial.

5. Use the jar with the solid sodium bisulfate acid and add another 1g of acid to the sample.

6. Cap the vial and shake thoroughly again.

7. When done, open the vial and check the pH of the acid solution with a new piece of pH paper.

    - If the pH paper reads below 2 then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar and one extra gram of acid.

    - Make a note of the extra gram of acid needed so the same amount of acid can be added to the vials the lab will analyze.

    - If the pH paper reads above 2, then add another gram of acid and repeat this procedure one more time.

Now that the soil chemistry has been determined, the actual sampling can occur. The procedure stated below assumes the correct vials are used based on the guidance discussed.

Sample Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.

2. Quickly collect a 5g sample using a cut off plastic syringe or other coring device designed to deliver 5g of soil from a freshly exposed surface of soil.

3. Carefully wipe exterior of sample collection device with a clean paper towel.

4. Quickly transfer to the appropriate VOA vial, extruding with caution so that the solution does not splash out of the vial.

5. Add more acid if necessary (this is based on the buffering testing discussed in the previous section).

6. Use the paper toweling and quickly remove any soil off the vial threads.

7. Cap vial and weigh the jar to the nearest 0.01g.

8. Record exact weight on sample label.

9. Repeat sampling procedure for the duplicate VOA vial.

10. Weigh the vial containing methanol preservative to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation below.

11. Take the empty jar or the jar that contains the methanol preservative.

12. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil. The 25g or 5g size is dependent on who is doing the sampling and who is doing the laboratory analysis.

13. Carefully wipe the exterior of the collection device with a clean paper towel.

14. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial. Again, the type of jar received is dependent on who is doing the laboratory analysis.

15. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.

16. Use the paper toweling and remove any soil off of the vial threads and cap the jar.

17. Weigh the jar with the soil in it to the nearest 0.01g and record the weight on the sample label.

18. Collect dry weight sample-fill container.

19. Store samples at 4° Celsius.

20. Ship sample containers with plenty of ice in accordance with Department of Transportation (DOT) regulations (CORROSIVE. FLAMMABLE LIQUID. POISON) to the laboratory.

5.2.2.3 EN CORE™ SAMPLER COLLECTION FOR HIGH LEVEL ANALYSES (≥200 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for high-level analysis:

- One 25g sampler or one 5g sampler (The sampler size used will be dependent on who is doing the sampling and who is doing the laboratory analysis).
- One dry weight cup.
- One T-handle.
- Paper towels.

EN CORE™ Sampling Steps for High Level Analysis

1. Remove sample and cap from package and attach T-handle to sampler body.

2. Quickly push the sampler into a freshly exposed surface of soil until the sampler is full.

3. Use paper toweling to quickly wipe the sampler head so that the cap can be tightly attached.

4. Push cap on with a twisting motion to attach cap.

5. Fill out a sample label and attach to sampler.

6. Collect dry weight sample.

7. Store samplers at 4° Celsius.

8. Ship sample containers with plenty of ice to the laboratory within 40 hours of collection.

NOTE: Verify state requirements for extraction/holding times.

5.2.2.4 METHANOL PRESERVATION SAMPLING FOR HIGH LEVEL ANALYSES (≥200 UG/KG)

Methanol Preservation Sampling Equipment Requirements

- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (laboratory grade).
- One dry weight cup.
- Weighing balance that accurately weighs to 0.01g (with accuracy of ±0.1g).
- Set of balance weights used in daily balance calibration.
- Latex gloves.
- Paper towel.
- Cutoff plastic syringe or other coring device to deliver 5g or 25g of soil.

Sampling Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.

2. Weigh the vial containing methanol preservative to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation/collection below.

3. Take the empty jar or the jar that contains the methanol preservative.

4. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil. The 25g or 5g size used is dependent on who is doing the sampling and who is doing the laboratory analysis.

5. Carefully wipe the exterior of the collection device with a clean paper towel.

6. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial. Again, the type of jar used is dependent on who is doing the laboratory analysis.

7. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.

8. Using the paper toweling, remove any soil off of the vial threads and cap the jar.

9. Weigh the jar with the soil in it to the nearest 0.01g and record the weight on the sample label.

10. Collect dry weight sample-fill container.

11. Store samples at 4° Celsius.

12. Ship sample containers with plenty of ice in accordance with DOT regulations (CORROSIVE. FLAMMABLE LIQUID. POISON) to the laboratory.

5.2.3 Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analysis

The requirements for collecting samples of surface soil for nonvolatile organic or inorganic analyses are as follows:

1. Label each sample container with the appropriate information. Secure the label by covering it with a piece of clear tape.

2. Use a decontaminated stainless steel or Teflon®-lined trowel or spoon to obtain sufficient sample from the required interval and subsampling points, if necessary, to fill the specified sample containers.

3. Empty the contents of each fill of the sampling device directly into a clean stainless steel or Teflon®-lined tray or bowl.

4. Homogenize the sample by mixing with a spoon, spatula, or trowel.

5. Use the spoon, spatula, or trowel to distribute the uniform mixture into the labeled sample containers. Fill organic sample containers first, then inorganics.

6. Secure the appropriate cap on each container immediately after filling it.

7. Wipe the sample containers with a clean Kimwipe or paper towel.

8. Place sample containers in individual zip-top plastic bags and seal the bags.

9. Pack all samples as required. Include properly completed documentation, and affix custody seals to the cooler lid.

10. Decontaminate sampling equipment according to CDM Federal SOP 4-5.

5.2.4 Manual (Hand) Augering Using a Tube Sampler With Liner

The following steps must be followed when collecting hand-augered samples using a tube sampler with liner:

1. Auger to the depth required for sampling. Place cuttings on the plastic sheeting as specified in the site-specific plans. If possible, lay out the cuttings in stratigraphic order.
2. Throughout augering, make detailed notes concerning the geologic features of the soil or sediments in the field logbook.
3. Cease augering when the top of the specified sampling depth has been reached. Remove the auger from the hole and decontaminate.
4. Prepare a decontaminated tube sampler by installing a decontaminated liner in the auger tube.
5. Obtain the sample and retrieve the auger. Remove the liner from the tube and immediately cover ends with Teflon® tape and cap the ends of the tube. Seal the caps with waterproof tape.
6. Label the sealed liners as required in the site-specific plans. Mark the top and bottom of the sample on the outside of the liner. Indicate boring/well number and depth on outside of liner.
7. Wipe sealed liners with a clean Kimwipe or paper towel.
8. Place sealed liners in zip-top plastic bags and seal the bags. Pack samples in a chilled cooler.
9. Proceed with further sampling, as required by the site-specific plans.
10. When sampling is complete, dispose of cuttings, plastic sheeting, etc., as specified in the site-specific plans.
11. Decontaminate all equipment according to CDM Federal SOP 4-5.
12. Complete the field logbook entry and other forms, being sure to record all relevant information before leaving the site.
13. Properly package all samples for shipment and complete all necessary sample shipment documentation. Remand custody of samples to the appropriate personnel. See CDM Federal SOPs 1-2 and 2-1 or site-specific plans.

5.2.5 Split-Spoon Sampling

The following steps must be followed when collecting split-spoon samples:

1. Remove any pavement and subbase material from an area of twice the bit diameter, if necessary.

2. The drilling rig will be decontaminated at a separate location prior to drilling, per CDM Federal SOP 4-5 or the site-specific decontamination procedures.

3. Attach the hollow-stem auger with the cutting head, plug, and center rod(s) to the drill rig.

4. Begin drilling and proceed to the first designated sample depth, adding auger flight(s) as necessary.

5. Slightly raise the auger flight(s) to disengage the cutting head, and rotate the auger without advancement to clean cuttings from the bottom of the hole.

6. Remove the plug and center rods.

7. Install a decontaminated split spoon on the center rod(s) and insert it into the hollow-stem auger. Connect the hammer assembly and lightly tap the rods to seat the drive shoe at the top of undisturbed soil or sediment.

8. Mark the center rod in 6-inch increments from the top of the auger flight(s).

9. Drive the spoon using the hammer. Use a full 30-inch drop as specified by the American Society for Testing and Materials (ASTM) Method D-1586. Record the number of blows required to drive the spoon or tube through each 6-inch increment.

10. Cease driving when the full length of the spoon has been driven or upon refusal. Refusal occurs when little (<1 inch) or no progress is made for 50 blows of the hammer.

11. Pull the spoon or tube free by using upswings of the hammer to loosen the sampler. Pull out the center rod and spoon or tube.

12. Unscrew the split-spoon assembly from the center rod and place it on the plastic sheeting.

13. Remove the drive shoe and head assembly. If necessary, tap the split-spoon assembly with a hammer to loosen threaded couplings.

14. With the drive shoe and head assembly off, open (split) the spoon, being careful not to disturb the sample.

15. Label sample containers with appropriate information. Secure the label, covering it with a piece of clear tape.

16. If VOC analyses are to be conducted on the soil sample, place that sample in its sample container immediately after opening the spoon, filling the sample bottle completely. Seal the container immediately, then describe it in the field logbook and/or associated forms. Record the sample identification number, depth from which the sample was taken, and the analyses to be performed on the samples in the field logbook and on the appropriate forms.

17. Remaining sample should be homogenized prior to placing samples in appropriate containers. Label containers as required.

18. Wipe containers with a clean Kimwipe or paper towel.

19. Place containers in zip-top plastic bags and seal the bags. Pack samples in a chilled cooler.

20. Continue to advance the borehole to the next sampling point. Collect samples as outlined above.

21. When sampling is complete, remove the drilling rig to the heavy equipment decontamination area.

22. Dispose of cuttings, plastic sheeting, etc., as specified in the site-specific plans. Backfill bore hole as specified in project-specific plans.

23. Decontaminate split spoons and other small sampling equipment according to CDM Federal SOP 4-5 before proceeding to other sampling locations.

24. Complete the field logbook entry and other forms, being sure to record all relevant information before leaving the site.

25. Properly package all samples for shipment to laboratories and complete all necessary sample shipment documentation. Remand custody of the samples to the appropriate personnel. See CDM Federal SOPs 1-2 and 2-1 or site-specific plans.

5.2.6 Split-Spoon Sampling Using Liners

The following steps must be followed when collecting samples with lined split spoons:

1. Remove any pavement and sub base material from an area of twice the bit diameter, if necessary.

2. The drilling rig will be decontaminated at a separate location prior to drilling.

3. Attach the hollow-stem auger with the cutting head and center rod(s).

4. Begin drilling and proceed to the first designated sample depth, adding auger flight(s) as necessary.

5. Slightly raise the auger flight(s) to disengage the cutting head, and rotate the auger without advancement to clean cuttings from the bottom of the hole.

6. Remove the plug and center rods.

7. Install decontaminated liners in the split-spoon barrel.

8. Install a decontaminated split spoon on the center rod(s) and insert it into the hollow-stem auger. Connect the hammer assembly and lightly tap the rods to seat the drive shoe at the top of undisturbed soil or sediment.

9. Mark the center rod in 6-inch increments from the top of the auger flight(s).

10. Drive the spoon using the hammer. Use a full 30-inch drop as specified by ASTM Method D-1586. Record the number of blows required to drive the spoon or tube through each 6-inch increment.

11. Cease driving when the full length of the spoon has been driven or upon refusal. Refusal occurs when little (<1 inch) or no progress is made after 50 blows of the hammer.

12. Pull the spoon or tube free by using upswings of the hammer to loosen the sampler. Pull out the center rod and spoon or tube.

13. Unscrew the split-spoon assembly from the center rod and place it on the plastic sheeting.

14. Remove the drive shoe and head assembly. If necessary, tap the split-spoon assembly with a hammer to loosen threaded couplings.

15. With the drive shoe and head assembly off, open (split) the spoon and remove the liners without disturbing the sample.

16. Immediately install Teflon® tape over the ends of the liners, cap the liners, and seal the caps over the ends of the liner with waterproof tape. Label the samples as required by the site-specific plans. Mark the top and bottom of each sample on the outside of each liner. Indicate boring/well number and depth on outside of liner.

17. Wipe sealed liners with a clean Kimwipe or paper towel.

18. Place sealed liners in zip-top plastic bags and seal the bags. Pack samples in a chilled cooler.

19. In the field logbook and on the boring log, describe sample lithology by observing cuttings and the bottom end of the sample in the liner.

20. Continue to advance the borehole to the next sampling point. Collect samples as outlined above.

21. When sampling is complete, remove the drilling rig to the heavy equipment decontamination site.

22. Dispose of cuttings, plastic sheeting, etc., as specified in the site-specific plans.

23. Decontaminate split spoons and other small sampling equipment before proceeding to other sampling locations as required by the CDM Federal SOP 4-5.

24. Complete the field logbook entry, and other forms, being sure to record all relevant information before leaving the site.

25. Properly package all samples for shipment to laboratories and complete all necessary sample shipment documentation. Remand custody of the samples to the appropriate personnel. See CDM Federal SOPs 1-2 and 2-1 or site-specific plans.

5.2.7 Shelby Tube Sampling

The following steps must be followed when collecting samples using the Shelby tube:

1. Remove any pavement and sub base material from an area of twice the bit diameter, if necessary.

2. The drilling rig will be decontaminated at a separate location prior to drilling.

3. Attach the hollow-stem auger with the cutting head, plug, and center rod(s).

4. Begin drilling and proceed to the first designated sample depth, adding auger flight(s) as necessary.

5. Slightly raise the auger flight(s) to disengage the cutting head, and rotate the auger without advancement to clean cuttings from the bottom of the hole.

6. Remove the plug and center rods.

7. Attach a head assembly to a decontaminated Shelby tube. Attach the Shelby tube assembly to the center rods.

8. Lower the Shelby tube and center rods into the hollow-stem augers and seat it at the bottom. Be sure to leave 30 inches or more of center rod above the lowest point to the hydraulic piston's extension.

9. Use the rig's hydraulic drive to push the Shelby tube into undisturbed soil. The tube should be pushed with a steady force. Note the pressure used to push the Shelby tube in the field logbook.

10. When the Shelby tube has been advanced its full length or to refusal, back off the hydraulic pistons. Attach a hoisting plug to the upper end of the center rod, twist to break off the sample, and pull the apparatus out of the hole with the rig winch.

11. Retrieve the Shelby tube to the surface, detach it from the center rod, and remove the head assembly.

12. Since the typical intent of Shelby tube sampling is for engineering purposes and an undisturbed sample is required, the tube ends should be sealed immediately. Sealing is accomplished by filling any void space in the tube with beeswax, then placing caps on the ends of the tube and taping caps into place. The top and bottom ends of the tube should be marked and the tube transported to the laboratory in an upright position. Indicate boring/well number and depth on outside of liner.

13. Wipe sealed tubes with a clean Kimwipe or paper towel.

14. Place sealed tubes in zip-top plastic bags and seal bags. Pack samples in a chilled cooler.

15. Continue to advance the borehole to the next sampling point. Collect samples as outlined above

16. When sampling is complete, remove the drilling rig to the heavy equipment decontamination area.

17. Dispose of cuttings, plastic sheeting, etc., as specified in the site-specific plans.

18. Complete the field logbook entry, being sure to record all relevant information before leaving the site. These methods may be used if directed by the EPA region, client or governing sample plan.

6.0 RESTRICTIONS/LIMITATIONS

Basket or spring retainers may be needed for split-spoon sampling in loose, sandy soils.

Shelby tubes may not retain the sample in loose, sandy soils.

7.0 REFERENCES

American Society for Testing and Materials, *Penetration Test And Split Barrel Sampling Of Soils*, Standard Method D-1586-84, 1984.

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Quality Control Requirements For Field Methods*, DOE/HWP-69/R1, July 1990.

U.S. Department of Energy, Hazardous Waste Remedial Actiors Program, *Standard Operating Procedures For Site Characterizations*, DOE/HWP-100/R2, September 1996 or current revision.

U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)*, Third Edition, November 1986, (as amended by Update III, June 1997). Method 5035: Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples.

Field Logbook Content and Control

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Approved: Michael C. Malloy 2/24/04
Signature/Date

Issued: 2/18/04
Signature/Date

1.0 Objective

The objective of this standard operating procedure (SOP) is to set CDM Federal (CDM) criteria for content entry and form of field logbooks. Field logbooks are an essential tool to document field activities for historical and legal purposes.

2.0 Background

2.1 Definitions

Biota - The flora and fauna of a region.

Magnetic Declination Corrections - Compass adjustments to correct for the angle between magnetic north and geographical meridians.

2.2 Discussion

Information recorded in field logbooks includes field team names, observations, data, calculations, date/time, weather, and description of the data collection activity, methods, instruments, and results. Additionally, the logbook may contain deviations from plans and descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

3.0 Responsibilities

Field Team Leader (FTL) - The FTL is responsible for ensuring that the format and content of data entries are in accordance with this procedure.

Site Personnel - All CDM employees who make entries in field logbooks during onsite activities are required to read this procedure prior to engaging in this activity. The FTL will assign field logbooks to site personnel who will be responsible for their care and maintenance. Site personnel will return field logbooks to the records file at the end of the assignment.

4.0 Required Equipment

- Site-specific plans
- Field notebook
- Indelible black or blue ink pen
- Ruler or similar scale

5.0 Procedures

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks must be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation. These procedures should be located at the field office.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. Prior to use in the field, each logbook will be marked with a specific document control number issued by the document control administrator, if required by the contract quality implementation plan (QIP). Not all contracts require document control numbers. The following information shall be recorded on the cover of the logbook:

- Field logbook document control number.
- Activity (if the logbook is to be activity-specific) and location.
- Name of CDM contact and phone number(s).
- Start date.
- In specific cases, special logbooks may be required (e.g., waterproof paper for stormwater monitoring).

The first few (approximately five) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading and enter the following:

Table of Contents

Date/Description	Page
(Start Date)/Reserved for TOC	1-5

The remaining pages of the table of contents will be designated as such with "TOC" written on the top center of each page.

5.2 Operation

Requirements that must be followed when using a logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information need not be duplicated in the logbook. However, any forms used to record site information must be referenced in the logbook.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.

Specific requirements for field logbook entries include:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- Multiple authors must sign out the logbook by inserting the following:
  Above notes authored by:
  - (Sign name)
  - (Print name)
  - (Date)
- A new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:
  - Date and time
  - Name of individual making entry
  - Names of field team and other persons onsite
  - Description of activity being conducted including station or location (i.e., well, boring, sampling location number) if appropriate
  - Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data
  - Level of personal protection to be used
  - Serial numbers of instruments
  - Required calibration information
  - Serial/tracking numbers on documentation (e.g., carrier air bills)

Entries into the field logbook shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In these cases, the logbook must reference the automatic data record or form.

At each station where a sample is collected or an observation or measurement made, a detailed description of the location of the station is required. Use a compass (include a reference to magnetic declination corrections), scale, or nearby survey markers, as appropriate. A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator. It is preferred that maps and sketches be oriented so that north is toward the top of the page. Maps, sketches, figures, or data that will not fit on a logbook page should be referenced and attached to the logbook to prevent separation.

Other events and observations that should be recorded include:

- Changes in weather that impact field activities.
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protection equipment.

5.3 Post-Operation

To guard against loss of data due to damage or disappearance of logbooks, completed pages shall be periodically photocopied (weekly, at a minimum) and forwarded to the field or project office. Other field records shall be photocopied and submitted regularly and as promptly as possible to the office. When possible, electronic media such as disks and tapes should be copied and forwarded to the project office.

At the conclusion of each activity or phase of site work, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated, and that corrections were made properly (single lines drawn through incorrect information, then initialed and dated). The completed logbook shall be submitted to the records file.

6.0 Restrictions/Limitations

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM personnel and their subcontractors. They are documents that may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these logbooks should be factual, clear, precise, and non-subjective. Field logbooks, and entries within, are not to be used for personal use.

7.0 References

Sandia National Laboratories, *Procedure for Preparing Sampling and Analysis Plan, Site-Specific Sampling Plan, and Field Operating Procedures*, QA-02-03, Albuquerque Environmental Program Department 3220, Albuquerque, New Mexico, 1991.

Sandia National Laboratories, Division 7723, *Field Operation Procedure for Field Logbook Content and Control, Environmental Restoration Department*, Albuquerque, New Mexico, 1992.

Prepared: David O. Johnson

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Approved: Michael C. Malley 2/24/04
Signature/Date

Issued: 2/18/04
Signature/Date

1.0 Objective

Due to the evidentiary nature of samples collected during environmental investigations, possession must be traceable from the time the samples are collected until their derived data are introduced as evidence in legal proceedings. To maintain and document sample possession, sample custody procedures are followed. All paperwork associated with the sample custody procedures will be retained in CDM Federal Programs Corporation (CDM) files unless the client requests that it be transferred to them for use in legal proceedings or at the completion of the contract.

Note: Sample custody documentation requirements vary with the specific EPA region or client. This SOP is intended to present basic sample custody requirements, along with common options. Specific sample custody requirements should be presented in the project-specific quality assurance (QA) project plan or project-specific modification or clarification form (see Section U-1).

2.0 Background

2.1 Definitions

Sample – A sample is material to be analyzed that is contained in single or multiple containers representing a unique sample identification number.

Sample Custody – A sample is under custody if:

1. It is in your possession
2. It is in your view, after being in your possession
3. It was in your possession and you locked it up
4. It is in a designated secure area

Chain-of-Custody Record – A chain-of-custody record is a form used to document the transfer of custody of samples from one individual to another.

Custody Seal – A custody seal is a tape-like seal that is part of the chain-of-custody process and is used to detect tampering with samples after they have been packed for shipping.

Sample Label – A sample label is an adhesive label placed on sample containers to designate a sample identification number and other sampling information.

Sample Tag – A sample tag is attached with string to a sample container to designate a sample identification number and other sampling information. Tags may be used when it is difficult to physically place adhesive labels on the container (e.g., in the case of small air sampling tubes).

3.0 Responsibilities

Sampler - The sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

Field Team Leader - The field team leader (FTL) is responsible for ensuring that strict chain-of-custody procedures are maintained during all sampling events. The FTL is also responsible for coordinating with the subcontractor laboratory to ensure that adequate information is recorded on custody records. The FTL determines whether proper custody procedures were followed during the fieldwork and decides if additional samples are required.

Field Sample Custodian - The field sample custodian, when designated by the FTL, is responsible for accepting custody of samples from the sampler(s) and properly packing and shipping the samples to the laboratory assigned to do the analyses. A field sample custodian is typically designated only for large and complex field efforts.

4.0 Required Supplies

- Chain-of-custody records (applicable client or CDM forms)
- Sample labels or tags
- Custody seals
- Clear tape

5.0 Procedures

5.1 Chain-of-Custody Record

This procedure establishes a method for maintaining custody of samples through use of a chain-of-custody record. This procedure will be followed for all samples collected or split samples accepted.

Field Custody

1. Collect only the number of samples needed to represent the media being sampled. To the extent possible, determine the quantity and types of samples and sample locations prior to the actual fieldwork. As few people as possible should handle samples.

2. Complete sample labels or tags for each sample using waterproof ink.

3. Maintain personal custody of the samples (in your possession) at all times until custody is transferred for sample shipment or directly to the analytical laboratory.

Transfer of Custody and Shipment

1. Complete a chain-of-custody record for all samples (see Figure 1 for an example of a chain-of-custody record. Similar forms may be used when requested by the client). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the sample custodian in the appropriate laboratory.

   - The date/time will be the same for both signatures when custody is transferred directly to another person. When samples are shipped via common carrier (e.g., Federal Express), the date/time will not be the same for both signatures. Common carriers are not required to sign the chain-of-custody record.

- In all cases, it must be readily apparent that the person who received custody is the same person who relinquished custody to the next custodian.
- If samples are left unattended or a person refuses to sign, this must be documented and explained on the chain-of-custody record.

Note: If a field sample custodian has been designated, he/she may initiate the chain-of-custody record, sign, and date as the relinquisher. The individual sampler(s) must sign in the appropriate block, but does (do) not need to sign and date as a relinquisher (refer to Figure 1).

2. Package samples properly for shipment and dispatch to the appropriate laboratory for analysis. Each shipment must be accompanied by a separate chain-of-custody record. If a shipment consists of multiple coolers, samples in the coolers may be recorded on a single chain-of-custody record.

3. The original record will accompany the shipment, and the copies will be retained by the FTL and, if applicable, distributed to the appropriate sample coordinators. Freight bills will also be retained by the FTL as part of the permanent documentation. The shipping number from the freight bill shall be recorded on the applicable chain-of-custody record.

Procedure for Completing CDM Example Chain-of-Custody Record
The following procedure is to be used to fill out the CDM chain-of-custody record. The record provided herein (Figure 1) is an example chain-of-custody record. If another type of custody record (i.e., provided by the EPA contract laboratory program or a subcontract laboratory) is used to track the custody of samples, the custody record should be filled out in its entirety.

1. Record project number.
2. Record FTL for the project (if a field sample custodian has been designated, also record this name in the "Remarks" box).
3. Record the name and address of the laboratory to which samples are being shipped.
4. Enter the project name/location or code number.
5. Record overnight courier's airbill number.
6. Record sample location number.
7. Record sample number.
8. Note preservatives added to the sample.
9. Note media type (matrix) of the sample.
10. Note sample type (grab or composite).
11. Enter date of sample collection.
12. Enter time of sample collection in military time.

Figure 1
Example CDM Chain-of-Custody Record

CDM

125 Maiden Lane, 5th Floor
New York, NY 10038
(212) 785-9123
Fax: (212) 785-6114

CHAIN OF CUSTODY RECORD

PROJECT ID.	FIELD TEAM LEADER	LABORATORY AND ADDRESS	DATE SHIPPED
PROJECT NAME/LOCATION		LAB CONTRACT:	AIRBILL NO.

MEDIA TYPE	PRESERVATIVES	SAMPLE TYPE
1. Surface Water	1. HCl, pH <2	G = Grab
2. Groundwater	2. HNO3, pH <2	C = Composite
3. Leachate	3. NaOH, pH >12	
4. Field QC	4. H2SO4, pH <2	
5. Soil/Sediment	5. Zinc Acetate, pH >9	
6. Oil	6. Ice Only	
7. Waste	7. Not Preserved	
8. Other ______	8. Other ______	

SAMPLE LOCATION NO.	LABORATORY SAMPLE NUMBER	PRESERVATIVES ADDED	MEDIA TYPE	SAMPLE TYPE	20__ DATE	TIME SAMPLED	ANALYSES (List no. of containers submitted)								REMARKS (Note if MS/MSD)
1.															
2.															
3.															
4.															
5.															
6.															
7.															
8.															
9.															
10.															

SAMPLER SIGNATURES:

RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY (PRINT)	DATE/TIME	RECEIVED BY (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	

COMMENTS:

DISTRIBUTION: White and yellow copies accompany sample shipment to laboratory; yellow copy retained by laboratory. Pink copy retained by samplers. 1/98

Note: If requested by the client, different chain-of-custody records may be used. Copies of the template for this record may be obtained from the Chantilly Graphics Department.

13. When required by the client, enter the names or initials of the samplers next to the sample location number of the sample they collected.
14. List parameters for analysis and the number of containers submitted for each analysis.
15. Enter matrix spike/matrix spike duplicate (MS/MSD) if sample is for **laboratory** quality control or other remarks (e.g., sample depth).
16. Sign the chain-of-custody record(s) in the space provided. All samplers must sign each record.
17. If sample tags are used, record the sample tag number in the "Remarks" column.
18. The originator checks information entered in Items 1 through 16 and then signs the top left "Relinquished by" box, prints his/her name, and enters the current date and time (military).
19. Send the top two copies (usually white and yellow) with the samples to the laboratory; retain the third copy (usually pink) for the project files. Retain additional copies for the project file or distribute as required to the appropriate sample coordinators.
20. The laboratory sample custodian receiving the sample shipment checks the sample label information against the chain-of-custody record. Sample condition is checked and anything unusual is noted under "Remarks" on the chain-of-custody record. The laboratory custodian receiving custody signs in the adjacent "Received by" box and keeps the copy. The white copy is returned to CDM.

5.2 Sample Labels and Tags

Unless the client directs otherwise, sample labels or tags will be used for all samples collected or accepted for CDM projects.

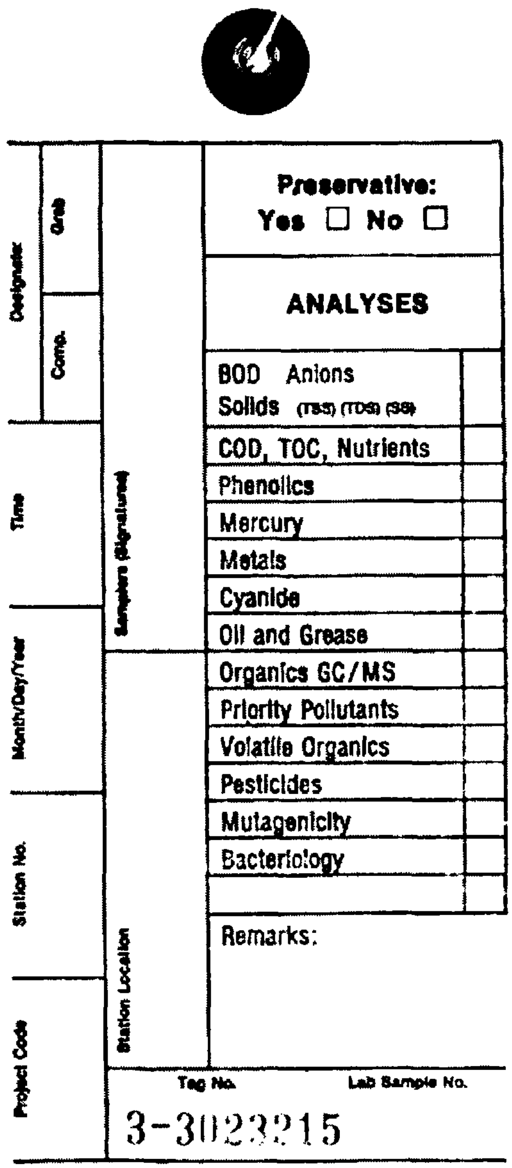
1. Complete one label or tag with the information required by the client for each sample container collected. A typical label or tag would be completed as follows (see Figure 2 for example of sample tag; labels are completed with the equivalent information):

   - Record the project code (i.e., project or task number).
   - Enter the station number (sample number) if applicable.
   - Record the date to indicate the month, day, and year of sample collection.
   - Enter the time (military) of sample collection.
   - Place a check to indicate composite or grab sample.
   - Record the station (sample) location.
   - Sign in the space provided.
   - Place a check next to "yes" or "no" to indicate if a preservative was added.
   - Place a check under "Analyses" next to the parameters for which the sample is to be analyzed. If the desired analysis is not listed, write it in the empty slot. **Note**: Do not write in the box for "laboratory sample number."
   - Place or write additional relevant information under "Remarks."

2. Place adhesive labels directly on the sample containers. Place clear tape over the label to protect from moisture.

3. Securely attach sample tags to the sample bottle. On 2.27 liter (80 oz.) amber bottles, the tag string may be looped through the ring style handle and tied. On all other containers, it is

Figure 2
Example Sample Tag



Note: Equivalent sample labels or tags may be used.

recommended that the string be looped around the neck of the bottle, then twisted and re-looped around the neck until the slack in the string is removed.

4. Double-check that the information recorded on the sample tag is consistent with the information recorded on the chain-of-custody record.

5.3 Custody Seals

Two custody seals must be placed on opposite corners of all shipping containers (e.g., cooler) prior to shipment. The seals should be signed and dated by the shipper.

Custody seals may also be placed on individual sample bottles. Check with the client or refer to EPA regional guidelines for direction.

5.4 Sample Shipping

The CDM standard operating procedure listed below defines the requirements for packaging and shipping environmental samples.

- CDM Federal SOP 2-1, Packaging and Shipping Environmental Samples

6.0 Restrictions/Limitations

Check with the EPA region or client for specific guidelines. If no specific guidelines are identified, this procedure should be followed.

For EPA Contract Laboratory Program (CLP) sampling events, combined chain-of-custody/traffic report forms or other EPA-specific records may be used. Refer to regional guidelines for completing these forms.

The EPA FORMS II Lite™ software may be used to customize sample labels and custody records when directed by the client or the CDM project manager.

7.0 References

U.S. Environmental Protection Agency, *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5, EPA/600/R-98/018, February 1998, Section B3.

U.S. Environmental Protection Agency, *National Enforcement Investigations Center, Multi-Media Investigation Manual*, EPA-330/9-89-003-R, Revised March 1992, p.85.

U.S. Environmental Protection Agency, *Contract Laboratory Program (CLP), Guidance for Field Samplers*, EPA-540-R-00-003, Draft Final, June 2001, Section 3.2.

U.S. Environmental Protection Agency, *FORMS II Lite™ User's Guide*, March 2001.

U.S. Environmental Protection Agency, Region IV, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, May 1996, Section 3.3.

U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plan*, EM 200-1-3, February 2001, Appendix F.

[Text Only]

Regulations (Standards - 29 CFR)

Work practices and engineering controls for Class I Asbestos Operations - non-mandatory - 1926.1101 App F

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** Z
- **Subpart Title:** Toxic and Hazardous Substances
- **Standard Number:** 1926.1101 App F
- **Title:** Work practices and engineering controls for Class I Asbestos Operations - non-mandatory

This is a non-mandatory appendix to the asbestos standards for construction and for shipyards. It describes criteria and procedures for erecting and using negative pressure enclosures for Class I Asbestos Work, when NPEs are used as an allowable control method to comply with paragraph (g)(5)(i) of this section. Many small and variable details are involved in the erection of a negative pressure enclosure. OSHA and most participants in the rulemaking agreed that only the major, more performance oriented criteria should be made mandatory. These criteria are set out in paragraph (g) of this section. In addition, this appendix includes these mandatory specifications and procedures in its guidelines in order to make this appendix coherent and helpful. The mandatory nature of the criteria which appear in the regulatory text is not changed because they are included in this "non-mandatory" appendix. Similarly, the additional criteria and procedures included as guidelines in the appendix, do not become mandatory because mandatory criteria are also included in these comprehensive guidelines.

In addition, none of the criteria, both mandatory and recommended, are meant to specify or imply the need for use of patented or licensed methods or equipment. Recommended specifications included in this attachment should not discourage the use of creative alternatives which can be shown to reliably achieve the objectives of negative-pressure enclosures.

Requirements included in this appendix, cover general provisions to be followed in all asbestos jobs, provisions which must be followed for all Class I asbestos jobs, and provisions governing the construction and testing of negative pressure enclosures. The first category includes the requirement for use of wet methods, HEPA vacuums, and immediate bagging of waste; Class I work must conform to the following provisions:

* oversight by competent person
* use of critical barriers over all openings to work area
* isolation of HVAC systems
* use of impermeable dropcloths and coverage of all objects within regulated areas

In addition, more specific requirements for NPEs include:

* maintenance of -0.02 inches water gauge within enclosure
* manometric measurements
* air movement away from employees performing removal work
* smoke testing or equivalent for detection of leaks and air direction
* deactivation of electrical circuits, if not provided with ground-fault circuit interrupters.

Planning the Project

The standard requires that an exposure assessment be conducted before the asbestos job is begun [Sec. 1926.1101 (f)(1)]. Information needed for that assessment, includes data relating to prior similar jobs, as applied to the specific variables of the current job. The information needed to conduct the assessment will be useful in planning the project, and in complying with any reporting requirements under this standard, when significant changes are being made to a control system listed in the standard, [see also those of USEPA (40 CFR 61, subpart M). Thus, although the standard does not explicitly require the preparation of a written asbestos removal plan, the usual constituents of such a plan, i.e., a description of the enclosure, the equipment, and the procedures to be used throughout the project, must be determined before the enclosure can be erected. The following information should be included in the planning of the system:

A physical description of the work area;
A description of the approximate amount of material to be removed;
A schedule for turning off and sealing existing ventilation systems;
Personnel hygiene procedures;
A description of personal protective equipment and clothing to be worn by employees;
A description of the local exhaust ventilation systems to be used and how they are to be tested;
A description of work practices to be observed by employees;
An air monitoring plan;
A description of the method to be used to transport waste material; and
The location of the dump site.

Materials and Equipment Necessary for Asbestos Removal

Although individual asbestos removal projects vary in terms of the equipment required to accomplish the removal of the materials, some equipment and materials are common to most asbestos removal operations.

Plastic sheeting used to protect horizontal surfaces, seal HVAC openings or to seal vertical openings and ceilings should have a minimum thickness of 6 mils. Tape or other adhesive used to attach plastic sheeting should be of sufficient adhesive strength to support the weight of the material plus all stresses encountered during the entire duration of the project without becoming detached from the surface.

Other equipment and materials which should be available at the beginning of each project are:

-- HEPA Filtered Vacuum is essential for cleaning the work area after the asbestos has been removed. It should have a long hose capable of reaching out-of-the-way places, such as areas above ceiling tiles, behind pipes, etc.
-- Portable air ventilation systems installed to provide the negative air pressure and air removal from the enclosure must be equipped with a HEPA filter. The number and capacity of units required to ventilate an enclosure depend on the size of the area to be ventilated. The filters for these systems should be designed in such a manner that they can be replaced when the air flow volume is reduced by the build-up of dust in the filtration material. Pressure monitoring devices with alarms and strip chart recorders attached to each system to indicate the pressure differential and the loss due to dust buildup on the filter are recommended.
-- Water sprayers should be used to keep the asbestos material as saturated as possible during removal; the sprayers will provide a fine mist that minimizes the impact of the spray on the material.
-- Water used to saturate the asbestos containing material can be amended by adding at least 15 milliliters (1/4 ounce) of wetting agent in 1 liter (1 pint) of water. An example of a wetting agent is a 50/50 mixture of polyoxyethylene ether and polyoxyethylene polyglycol ester.
-- Backup power supplies are recommended, especially for ventilation systems.
-- Shower and bath water should be with mixed hot and cold water faucets. Water that has been used to clean personnel or equipment should either be filtered or be collected and discarded as asbestos waste. Soap and shampoo should be provided to aid in removing dust from the workers' skin and hair.
-- See paragraphs (h) and (i) of this section for appropriate respiratory protection and protective clothing.
-- See paragraph (k) of this section for required signs and labels.

Preparing the Work Area

Disabling HVAC Systems: The power to the heating, ventilation, and air conditioning systems that service the restricted area must be deactivated and locked off. All ducts, grills, access ports, windows and vents must be sealed off with two layers of plastic to prevent entrainment of contaminated air.

Operating HVAC Systems in the Restricted Area: If components of a HVAC system located in the restricted area are connected to a system that will service another zone during the project, the portion of the duct in the restricted area must be sealed and pressurized. Necessary precautions include caulking the duct joints, covering all cracks and openings with two layers of sheeting, and pressurizing the duct throughout the duration of the project by restricting the return air flow. The power to the fan supplying the positive pressure should be locked "on" to prevent pressure loss.

Sealing Elevators: If an elevator shaft is located in the restricted area, it should be either shut down or isolated by sealing with two layers of plastic sheeting. The sheeting should provide enough slack to accommodate the pressure changes in the shaft without breaking the air-tight seal.

Removing Mobile Objects: All movable objects should be cleaned and removed from the work area before an enclosure is constructed unless moving the objects creates a hazard. Mobile objects will be assumed to be contaminated and should be either cleaned with amended water and a HEPA vacuum and then removed from the area or wrapped and then disposed of as hazardous waste.

Cleaning and Sealing Surfaces: After cleaning with water and a HEPA vacuum, surfaces of stationary objects should be covered with two layers of plastic sheeting. The sheeting should be secured with duct tape or an equivalent method to provide a tight seal around the object.

Bagging Waste: In addition to the requirement for immediate bagging of waste for disposal, it is further recommended that the waste material be double-bagged and sealed in plastic bags designed for asbestos disposal. The bags should be stored in a waste storage area that can be controlled by the workers conducting the removal. Filters removed from air handling units and rubbish removed from the area are to be bagged and handled as hazardous waste.

Constructing the Enclosure

The enclosure should be constructed to provide an air-tight seal around ducts and openings into existing ventilation systems and around penetrations for electrical conduits, telephone wires, water lines, drain pipes, etc. Enclosures should be both airtight and watertight except for those openings designed to provide entry and/or air flow control.

Size: An enclosure should be the minimum volume to encompass all of the working surfaces yet allow unencumbered movement by the worker(s), provide unrestricted air flow past the worker(s), and ensure walking surfaces can be kept free of tripping hazards.

Shape: The enclosure may be any shape that optimizes the flow of ventilation air past the worker(s).

Structural Integrity: The walls, ceilings and floors must be supported in such a manner that portions of the enclosure will not fall down during normal use.

Openings: It is not necessary that the structure be airtight; openings may be designed to direct air flow. Such openings should be located at a distance from active removal operations. They should be designed to draw air into the enclosure under all anticipated circumstances. In the event that negative pressure is lost, they should be fitted with either HEPA filters to trap dust or automatic trap doors that prevent dust from escaping the enclosure. Openings for exits should be controlled by an airlock or a vestibule.

Barrier Supports: Frames should be constructed to support all unsupported spans of sheeting.

Sheeting: Walls, barriers, ceilings, and floors should be lined with two layers of plastic sheeting having a thickness of at least 6 mil.

Seams: Seams in the sheeting material should be minimized to reduce the possibilities of accidental rips and tears in the adhesive or connections. All seams in the sheeting should overlap, be staggered and not be located at corners or wall-to-floor joints. Areas Within an Enclosure: Each enclosure consists of a work area, a decontamination area, and waste storage area. The work area where the asbestos removal operations occur should be separated from both the waste storage area and the contamination control area by physical curtains, doors, and/or airflow patterns that force any airborne contamination back into the work area.

See paragraph (j) of this section for requirements for hygiene facilities.

During egress from the work area, each worker should step into the equipment room, clean tools and equipment, and remove gross contamination from clothing by wet cleaning and HEPA vacuuming. Before entering the shower area, foot coverings, head coverings, hand coverings, and coveralls are removed and placed in impervious bags for disposal or cleaning. Airline connections from airline respirators with HEPA disconnects and power cables from powered air-purifying respirators (PAPRs) will be disconnected just prior to entering the shower room.

Establishing Negative Pressure Within the Enclosure

Negative Pressure: Air is to be drawn into the enclosure under all anticipated conditions and exhausted through a HEPA filter for 24 hours a day during the entire duration of the project.

Air Flow Tests: Air flow patterns will be checked before removal operations begin, at least once per operating shift and any time there is a question regarding the integrity of the enclosure. The primary test for air flow is to trace air currents with smoke tubes or other visual methods. Flow checks are made at each opening and at each doorway to demonstrate that air is being drawn into the enclosure and at each worker's position to show that air is being drawn away from the breathing zone.

Monitoring Pressure Within the Enclosure: After the initial air flow patterns have been checked, the static pressure must be monitored within the enclosure. Monitoring may be made using manometers, pressure gauges, or combinations of these devices. It is recommended that they be attached to alarms and strip chart recorders at points identified by the design engineer.

Corrective Actions: If the manometers or pressure gauges demonstrate a reduction in pressure differential below the required level, work should cease and the reason for the change investigated and appropriate changes made. The air flow patterns should be retested before work begins again.

Pressure Differential: The design parameters for static pressure differentials between the inside and outside of enclosures typically range from 0.02 to 0.10 inches of water gauge, depending on conditions. All zones inside the enclosure must have less pressure than the ambient pressure outside of the enclosure (-0.02 inches water gauge differential). Design specifications for the differential vary according to the size, configuration, and shape of the enclosure as well as ambient and mechanical air pressure conditions around the enclosure.

Air Flow Patterns: The flow of air past each worker shall be enhanced by positioning the intakes and exhaust ports to remove contaminated air from the worker's breathing zone, by positioning HEPA vacuum cleaners to draw air from the worker's breathing zone, by forcing relatively uncontaminated air past the worker toward an exhaust port, or by using a combination of methods to reduce the worker's exposure.

Air Handling Unit Exhaust: The exhaust plume from air handling units should be located away from adjacent personnel and intakes for HVAC systems.

Air Flow Volume: The air flow volume (cubic meters per minute) exhausted (removed) from the workplace must exceed the amount of makeup air supplied to the enclosure. The rate of air exhausted from the enclosure should be designed to maintain a negative pressure in the enclosure and air movement past each worker. The volume of air flow removed from the enclosure should replace the volume of the container at every 5 to 15 minutes. Air flow volume will need to be relatively high for large enclosures, enclosures with awkward shapes, enclosures with multiple openings, and operations employing several workers in the enclosure.

Air Flow Velocity: At each opening, the air flow velocity must visibly "drag" air into the enclosure. The velocity of air flow within the enclosure must be adequate to remove airborne contamination from each worker's breathing zone without disturbing the asbestos-containing material on surfaces.

Airlocks: Airlocks are mechanisms on doors and curtains that control the air flow patterns in the doorways. If air flow occurs, the patterns through doorways must be such that the air flows toward the inside of the enclosure. Sometimes vestibules, double doors, or double curtains are used to prevent air movement through the doorways. To use a vestibule, a worker enters a chamber by opening the door or curtain and then closing the entry before opening the exit door or curtain.

Airlocks should be located between the equipment room and shower room, between the shower room and the clean room, and between the waste storage area and the outside of the enclosure. The air flow between adjacent rooms must be checked using smoke tubes or other visual tests to ensure the flow patterns draw air toward the work area without producing eddies.

Monitoring for Airborne Concentrations

In addition to the breathing zone samples taken as outlined in paragraph (f) of this section, samples of air should be taken to demonstrate the integrity of the enclosure, the cleanliness of the clean room and shower area, and the effectiveness of the HEPA filter. If the clean room is shown to be contaminated, the room must be relocated to an uncontaminated area.

Samples taken near the exhaust of portable ventilation systems must be done with care.

General Work Practices

Preventing dust dispersion is the primary means of controlling the spread of asbestos within the enclosure. Whenever practical, the point of removal should be isolated, enclosed, covered, or shielded from the workers in the area. Waste asbestos containing materials must be bagged during or immediately after removal; the material must remain saturated until the waste container is sealed.

Waste material with sharp points or corners must be placed in hard air-tight containers rather than bags.

Whenever possible, large components should be sealed in plastic sheeting and removed intact.

Bags or containers of waste will be moved to the waste holding area, washed, and wrapped in a bag with the appropriate labels.

Cleaning the Work Area

Surfaces within the work area should be kept free of visible dust and debris to the extent feasible. Whenever visible dust appears on surfaces, the surfaces within the enclosure must be cleaned by wiping with a wet sponge, brush, or cloth and then vacuumed with a HEPA vacuum.

All surfaces within the enclosure should be cleaned before the exhaust ventilation system is deactivated and the enclosure is disassembled. An approved encapsulant may be sprayed onto areas after the visible dust has been removed.

[59 FR 40964, Aug. 10, 1994; 60 FR 33972, June 29, 1995]

Next Standard (1926.1101 App G)

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Occupational Safety & Health Administration
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ASBESTOS SAMPLING

1.0 SCOPE AND APPLICATION

Asbestos has been used in many commercial products including building materials such as flooring tiles and sheet goods, paints and coatings, insulation, and roofing asphalts. These products and others may be found at hazardous waste sites hanging on overhead pipes, contained in drums, abandoned in piles, or as part of a structure. Asbestos tailing piles from mining operations can also be a source of ambient asbestos fibers. Asbestos is a known carcinogen and requires air sampling to assess airborne exposure to human health. This Standard Operating Procedure (SOP) provides procedures for asbestos air sampling by drawing a known volume of air through a mixed cellulose ester (MCE) filter. The filter is then sent to a laboratory for analysis. The U.S. Environmental Protection Agency/Environmental Response Team (U.S. EPA/ERT) uses one of four analytical methods for determining asbestos in air. These include: U.S. EPA's *Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air for Transmission Electron Microscopy (TEM)*[1]; U.S. EPA's Modified Yamate Method for TEM[2]; National Institute for Occupational Safety and Health (NIOSH) Method 7402 (direct method only) for TEM; and NIOSH Method 7400 for Phase Contrast Microscopy (PCM)[3]. Each method has specific sampling and analytical requirements (i.e., sample volume and flow rate) for determining asbestos in air.

The U.S. EPA/ERT typically follows procedures outlined in the TEM methods for determining mineralogical types of asbestos in air and for distinguishing asbestos from non-asbestos minerals. The Phase Contrast Microscopy (PCM) method is used by U.S. EPA/ERT as a screening tool since it is less costly than TEM. PCM cannot distinguish asbestos from non-asbestos fibers, therefore the TEM method may be necessary to confirm analytical results. For example, if an action level for the presence of fibers has been set and PCM analysis indicates that the action level has been exceeded, then TEM analysis can be used to quantify and identify asbestos structures through examination of their morphology crystal structures (through electron diffraction), and elemental composition (through energy dispersive X-ray analysis). In this instance samples should be collected for both analyses in side by side sampling trains (some laboratories are able to perform PCM and TEM analysis from the same filter). The Superfund method is designed specifically to provide results suitable for supporting risk assessments at Superfund sites, it is applicable to a wide range of ambient air situations at hazardous waste sites. U.S. EPA's Modified Yamate Method for TEM is also used for ambient air sampling due to high volume requirements. The PCM and TEM NIOSH analytical methods require lower sample volumes and are typically used indoors; however, ERT will increase the volume requirement for outdoor application.

Other Regulations pertaining to asbestos have been promulgated by U.S. EPA and OSHA. U.S. EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) regulates asbestos-containing waste materials. NESHAP establishes management practices and standards for the handling of asbestos and emissions from waste disposal operations (40 CFR Part 61, Subparts A and M). U.S. EPA's 40 CFR 763 (July 1, 1987)[4] and its addendum 40 CFR 763 (October 30, 1987)[4] provide comprehensive rules for the asbestos abatement industry. State and local regulations on these issues vary and may be more stringent than federal requirements. The OSHA regulations in 29 CFR 1910.1001 and 29 CFR 1926.58 specify work practices and safety equipment such as respiratory protection and protective clothing when handling asbestos. The OSHA standard for an 8-hour, time-weighted average (TWA) is 0.2 fibers/cubic centimeters of air. This standard pertains to fibers with a length-to-width ratio of 3 to 1 with a fiber length >5 µm[5,6]. An action level of 0.1 fiber/cc (one-half the OSHA standard) is the level U.S. EPA has established in which employers must initiate such activities as air monitoring, employee training, and medical surveillance[5,6].

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Prior to sampling, the site should be characterized by identifying on-site as well as off-site sources of airborne asbestos. The array of sampling locations and the schedule for sample collection, is critical to the success of an investigation. Generally, sampling strategies to characterize a single point source are fairly straightforward, while multiple point sources and area sources increase the complexity of the sampling strategy. It is not within the scope of this SOP to provide a generic asbestos air sampling plan. Experience, objectives, and site characteristics will dictate the sampling strategy.

During a site investigation, sampling stations should be arranged to distinguish spatial trends in airborne asbestos concentrations. Sampling schedules should be fashioned to establish temporal trends. The sampling strategy typically requires that the concentration of asbestos at the source (worst case) or area of concern (downwind), crosswind, as well as background (upwind) contributions be quantified. See Table 1 (Appendix A) for U.S. EPA/ERT recommended sampling set up for ambient air. Indoor asbestos sampling requires a different type of strategy which is identified in Table 2 (Appendix A). It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks can be utilized to determine other sources.

Much information can be derived from each analytical method previously mentioned. Each analytical method has specific sampling requirements and produce results which may or may not be applicable to a specific sampling effort. The site sampling objectives should be carefully identified so as to select the most appropriate analytical method. Additionally, some preparation (i.e., lot blanks results) prior to site sampling may be required, these requirements are specified in the analytical methods.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Sample Preservation

No preservation is required for asbestos samples.

3.2 Sample Handling, Container and Storage Procedures

1. Place a sample label on the cassette indicating a unique sampling number. Do not put sampling cassettes in shirt or coat pockets as the filter can pick up fibers. The original cassette box is used to hold the samples.

2. Wrap the cassette individually in a plastic sample bag. Each bag should be marked indicating sample identification number, total volume, and date.

3. The wrapped sampling cassettes should be placed upright in a rigid container so that the cassette cap is on top and cassette base is on bottom. Use enough packing material to prevent jostling or damage. Do not use vermiculite as packing material for samples. If possible, hand carry to lab.

4. Provide appropriate documentation with samples (i.e., chain of custody and requested analytical methodology).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Flow rates exceeding 16 liters/minute (L/min) which could result in filter destruction due to (a) failure of its physical support under force from the increased pressure drop; (b) leakage of air around the filter mount so that the filter is bypassed, or (c) damage to the asbestos structures due to increased impact velocities.

4.1 U.S. EPA's Superfund Method

4.1.1 Direct-transfer TEM Specimen Preparation Methods

Direct-Transfer TEM specimen preparation methods have the following significant interferences:

- The achievable detection limit is restricted by the particulate density on the filter, which in turn is controlled by the sampled air volume and the total suspended particulate concentration in the atmosphere being sampled.
- The precision of the result is dependent on the uniformity of the deposit of asbestos structures on the sample collection filter.
- Air samples must be collected so that they have particulate and fiber loadings within narrow ranges. If too high a particulate loading occurs on the filter, it is not possible to prepare satisfactory TEM specimens by a direct-transfer method. If too high a fiber loading occurs on the filter, even if satisfactory TEM specimens can be prepared, accurate fiber counting will not be possible.

4.1.2 Indirect TEM Specimen Preparation Methods

Indirect TEM specimen preparation methods have the following interferences:

- The size distribution of asbestos structures is modified.
- There is increased opportunity for fiber loss or introduction of extraneous contamination.
- When sample collection filters are ashed, any fiber contamination in the filter medium is concentrated on the TEM specimen grid.

It can be argued that direct methods yield an under-estimate of the asbestos structure concentration because many of the asbestos fibers present are concealed by other particulate material with which they are associated. Conversely, indirect methods can be considered to yield an over-estimate because some types of complex asbestos structures disintegrate during the preparation, resulting in an increase in the numbers of structures counted.

4.2 U.S. EPA's Modified Yamate Method for TEM

High concentrations of background dust interfere with fiber identification.

4.3 NIOSH Method for TEM

Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fiber identification.

4.4 NIOSH Method for PCM

PCM cannot distinguish asbestos from non-asbestos fibers; therefore, all particles meeting the counting criteria are counted as total asbestos fibers. Fiber less than 0.25 um in length will not be detected by this method. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

5.0 EQUIPMENT/MATERIALS

5.1 Sampling Pump

The constant flow or critical orifice controlled sampling pump should be capable of a flow-rate and pumping time sufficient to achieve the desired volume of air sampled.

The lower flow personal sampling pumps generally provide a flow rate of 20 cubic centimeters/minute (cc/min) to 4 L/min. These pumps are usually battery powered. High flow pumps are utilized when flow rates between 2 L/min to 20 L/min are required. High flow pumps are used for short sampling periods so as to obtain the desired sample volume. High flow pumps usually run on AC power and can be plugged into a nearby outlet. If an outlet is not available then a generator should be obtained. The generator should be positioned downwind from the sampling pump. Additional voltage may be required if more than one pump is plugged into the same generator. Several electrical extension cords may be required if sampling locations are remote.

The recommended volume for the Superfund method (Phase I) requires approximately 20 hours to collect. Such pumps typically draw 6 amps at full power so that 2 lead/acid batteries should provide sufficient power to collect a full sample. The use of line voltage, where available, eliminates the difficulties associated with transporting stored electrical energy.

A stand should be used to hold the filter cassette at the desired height for sampling and the filter cassette shall be isolated from the vibrations of the pump.

5.2 Filter Cassette

The cassettes are purchased with the required filters in position, or can be assembled in a laminar flow hood or clean area. When the filters are in position, a shrink cellulose band or adhesive tape should be applied to cassette joints to prevent air leakage.

5.2.1 TEM Cassette Requirements

Commercially available field monitors, comprising 25 mm diameter three-piece cassettes, with conductive extension cowls shall be used for sample collection. The cassette must be new and not previously used. The cassette shall be loaded with an MCE filter of pore size 0.45 μm, and supplied from a lot number which has been qualified as low background for asbestos determination. The cowls should be constructed of electrically conducting material to minimize electrostatic effects. The filter shall be backed by a 5 μm pore size MCE filter (Figure 1, Appendix B).

5.2.2 PCM Cassette Requirements

NIOSH Method 7400, PCM involves using a 0.8 to 1.2 μm mixed cellulose ester membrane, 25 mm diameter, 50 mm conductive cowl on cassette (Figure 2, Appendix B). Some labs are able to perform PCM and TEM analysis on the same filter; however, this should be discussed with the laboratory prior to sampling.

5.3 Other Equipment

- Inert tubing with glass cyclone and hose barb
- Whirlbags (plastic bags) for cassettes
- Tools - small screw drivers
- Container - to keep samples upright
- Generator or electrical outlet (may not be required)
- Extension cords (may not be required)
- Multiple plug outlet
- Sample labels
- Air data sheets
- Chain of Custody records

6.0 REAGENTS

Reagents are not required for the preservation of asbestos samples.

7.0 PROCEDURES

7.1 Air Volumes and Flow Rates

Sampling volumes are determined on the basis of how many fibers need to be collected for reliable measurements. Therefore, one must estimate how many airborne fibers may be in the sampling location.

Since the concentration of airborne aerosol contaminants will have some effect on the sample, the following is a suggested criteria to assist in selecting a flow rate based on real-time aerosol monitor (RAM) readings in milligrams/cubic meter (mg/m^3).

	Concentration	Flow Rate
• Low RAM readings:	$<6.0\ mg/m^3$	11-15. L/min
• Medium RAM readings:	$>6.0\ mg/m^3$	7.5 L/min
• High RAM readings:	$>10.\ mg/m^3$	2.5 L/min

In practice, pumps that are available for environmental sampling at remote locations operate under a maximum load of approximately 12 L/min.

7.1.1 U.S. EPA's Superfund Method

The Superfund Method incorporates an indirect preparation procedure to provide flexibility in the amount of deposit that be can be tolerated on the sample filter and to allow for the selective concentration of asbestos prior to analysis. To minimize contributions to background contamination from asbestos present in the plastic matrices of membrane filters while allowing for sufficient quantities of asbestos to be collected, this method also requires the collection of a larger volume of air per unit area of filter than has traditionally been collected for asbestos analysis. Due to the need to collect large volumes of air, higher sampling flow rates are recommended in this method than have generally been employed for asbestos sampling in the past. As an alternative. samples may be collected over longer time intervals. However, this restricts the flexibility required to allow samples to be collected while uniform meteorological conditions prevail.

The sampling rate and the period of sampling should be selected to yield as high a sampled volume as possible. which will minimize the influence of filter contamination. Wherever possible, a volume of 15 cubic meters (15,000 L) shall be sampled for those samples intended for analysis only by the indirect TEM preparation method (Phase 1 samples). For those samples to be prepared by both the indirect and the direct specimen preparation methods (Phase 2 samples). the volumes must be adjusted so as to provide a suitably-loaded filter for the direct TEM preparation method. One option is to collect filters at several loadings to bracket the estimated optimum loading for a particular site. Such filters can be screened in the laboratory so that only those filters closest to optimal loading are analyzed. It has been found that the volume cannot normally exceed 5 cubic meters (5000 L) in an urban or agricultural area, and 10 cubic meters (10,000 L) in a rural area for samples collected on a 25 mm filter and prepared by a direct-transfer technique.

An upper limit to the range of acceptable flow rates for this method is 15 L/min. At many locations, wind patterns exhibit strong diurnal variations. Therefore, intermittent sampling (sampling over a fixed time interval repeated over several days) may be necessary to accumulate 20 hours of sampling time over constant wind conditions. Other sampling objectives also may necessitate intermittent sampling. The objective is to design a sampling schedule so that samples are collected under uniform conditions throughout the sampling interval. This method provides for such options. Air volumes collected on Phase I samples are maximized (<16 L/min). Air volumes collected on Phase 2 samples are limited to provide optimum loading for filters to be prepared by a direct-transfer procedure.

7.1.2 U.S. EPA's Modified Yamate Method for TEM

U.S. EPA's TEM method requires a minimum volume of 560 L and a maximum volume of 3,800 L in order to obtain an analytical sensitivity of 0.005 structures/cc. The optimal volume for TEM is 1200 L to 1800 L. These volumes are determined using a 200 mesh EM grid opening with a 25-mm filter cassette. Changes in volume would be necessary if a 37-mm filter cassette is used since the effective area of a 25 mm (385 sq mm) and 37 mm (855 sq m) differ.

7.1.3 NIOSH Method for TEM and PCM

The minimum recommended volume for TEM and PCM is 400 L at 0.1 fiber/cc. Sampling time is adjusted to obtain optimum fiber loading on the filter. A sampling rate of 1 to 4 L/min for eight hours (700 to 2800 L) is appropriate in non-dusty atmospheres containing 0.1 fiber/cc. Dusty atmospheres i.e., areas with high levels of asbestos, require smaller sample volumes (<400 L) to obtain countable samples.

In such cases, take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3,000 to 10,000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If > 50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration. Do not exceed 0.5 mg total dust loading on the filter.

7.2 Calibration Procedures

In order to determine if a sampling pump is measuring the flow rate or volume of air correctly, it is necessary to calibrate the instrument. Sampling pumps should be calibrated immediately before and after each use. Preliminary calibration should be conducted using a primary calibrator such as a soap bubble type calibrator, (e.g., a Buck Calibrator, Gilibrator, or equivalent primary calibrator) with a representative filter cassette installed between the pump and the calibrator. The representative sampling cassette can be reused for calibrating other pumps that will be used for asbestos sampling. The same cassette lot used for sampling should also be used for the calibration. A sticker should be affixed to the outside of the extension cowl marked "Calibration Cassette."

A rotameter can be used provided it has been recently precalibrated with a primary calibrator. Three separate constant flow calibration readings should be obtained both before sampling and after sampling. Should the flow rate change by more than 5% during the sampling period, the average of the pre- and post-calibration rates will be used to calculate the total sample volume. The sampling pump used shall provide a non-fluctuating air-flow through the filter, and shall maintain the initial volume flow-rate to within ± 10% throughout the sampling period. The mean value of these flow-rate measurements shall be used to calculate the total air volume sampled. A constant flow or critical orifice controlled pump meets these requirements. If at any time the measurement indicates that the flow-rate has decreased by more than 30%, the sampling shall be terminated. Flexible tubing is used to connect the filter cassette to the sampling pump.Sampling pumps can be calibrated prior to coming on-site so that time is saved when performing on-site calibration.

7.2.1 Calibrating a Personal Sampling Pump with an Electronic Calibrator

1. See Manufacturer's manual for operational instructions.

2. Set up the calibration train as shown in (Figure 3, Appendix B) using a sampling pump, electronic calibrator, and a representative filter cassette. The same lot sampling cassette used for sampling should also be used for calibrating.

3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 foot) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the electronic calibrator.

4. Turn the electronic calibrator and sampling pump on. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.

5. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.

6. Perform the calibration three times until the desired flow rate of ± 5% is attained.

7.2.2 Calibrating a Rotameter with an Electronic Calibrator

1. See manufacturer's manual for operational instructions.

2. Set up the calibration train as shown in (Figure 4, Appendix B) using a sampling pump, rotameter, and electronic calibrator.

3. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.

4. Turn the electronic calibrator and sampling pump on.

5. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.

6. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.

7. Record the electronic calibrator flow rate reading and the corresponding rotameter reading. Indicate these values on the rotameter (sticker). The rotameter should be able to work within the desired flow range. Readings can also be calibrated for 10 cm^3 increments for Low Flow rotameters, 500 cm^3 increments for medium flow rotameters and 1 liter increments for high flow rotameters.

8. Perform the calibration three times until the desired flow rate of ± 5% is attained. Once on site, a secondary calibrator, i.e., rotameter may be used to calibrate sampling pumps.

7.2.3 Calibrating a Personal Sampling Pump with a Rotameter

1. See manufacturer's manual for Rotameter's Operational Instructions.

2. Set up the calibration train as shown in (Figure 5, Appendix B) using a rotameter, sampling pump, and a representative sampling cassette.

3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 ft) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the rotameter.

4. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.

5. Turn the sampling pump on.

6. Turn the flow adjust screw (or knob) on the personal sampling pump until the float ball on the rotameter is lined up with the precalibrated flow rate value. A sticker on the rotameter should indicate this value.

7. A verification of calibration is generally performed on-site in the clean zone immediately prior to the sampling.

7.3. Meteorology

It is recommended that a meteorological station be established. If possible, sample after two to three days of dry weather and when the wind conditions are at 10 mph or greater. Record wind speed, wind direction, temperature, and pressure in a field logbook. Wind direction is particularly important when monitoring for asbestos downwind from a fixed source.

7.4 Ambient Sampling Procedures

7.4.1 Pre-site Sampling Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain necessary sampling equipment and ensure it is in working order and fully charged (if necessary).

3. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety plan.

4. Once on-site the calibration is performed in the clean zone. The calibration procedures are listed in Section 7.2.

5. After calibrating the sampling pump, mobilize to the sampling location.

7.4.2 Site Sampling

1. To set up the sampling train, attach the air intake hose to the cassette base. Remove the cassette cap (Figure 6 and 7, Appendix B). The cassette should be positioned downward, perpendicular to the wind

2. If AC or DC electricity is required then turn it on. If used, the generator should be placed 10 ft. downwind from the sampling pump.

3. Record the following in a field logbook: date, time, location, sample identification number, pump number, flow rate, and cumulative time.

4. Turn the pump on. Should intermittent sampling be required, sampling filters must be covered between active periods of sampling. To cover the sample filter: turn the cassette to face upward, place the cassette cap on the cassette, remove the inlet plug from the cassette cap, attach a rotameter to the inlet opening of the cassette cap to measure the flow rate, turn off the sampling pump, place the inlet plug into the inlet opening on the cassette cap. To resume sampling: remove the inlet plug, turn on the sampling pump, attach a rotameter to measure the flow rate, remove the cassette cap, replace the inlet plug in the cassette cap and invert the cassette, face downward and perpendicular to the wind.

5. Check the pump at sampling midpoint if sampling is longer than 4 hours. The generators may need to be regased depending on tank size. If a filter darkens in appearance or if loose dust is seen in the filter, a second sample should be started.

6. At the end of the sampling period, orient the cassette up, turn the pump off.

7. Check the flow rate as shown in Section 7.2.3. When sampling open-faced, the sampling cap should be replaced before post calibrating. Use the same cassette used for sampling for post calibration (increase dust/fiber loading may have altered the flow rate.

8. Record the post flow rate.

9. Record the cumulative time or run.

10. Remove the tubing from the sampling cassette. Still holding the cassette upright, replace the inlet plug on the cassette cap and the outlet plug on the cassette base.

7.4.3. Post Site Sampling

1. Follow handling procedures in Section 3.2, steps 1-4.

2. Obtain an electronic or hard copy of meteorological data which occurred during the sampling event. Record weather: wind speed, ambient temperature, wind direction, and precipitation. Obtaining weather data several days prior to the sampling event can also be useful.

7.5 Indoor Sampling Procedures

PCM analysis is used for indoor air samples. When analysis shows total fiber count above the OSHA action level 0.1 f/cc then TEM (U.S. EPA's Modified Yamate Method) is used to identify asbestos from non-asbestos fibers.

Sampling pumps should be placed four to five feet above ground level away from obstructions that may influence air flow. The pump can be placed on a table or counter. Refer to Table 2 (Appendix A) for a summary of indoor sampling locations and rationale for selection.

Indoor sampling utilizes high flow rates to increased sample volumes (2000 L for PCM and 2800 to 4200 L for TEM) in order to obtain lower detection limits below the standard, (i.e., 0.01 f/cc or lower [PCM] and 0.005 structures/cc or lower [TEM]).

7.5.1 Aggressive Sampling Procedures

Sampling equipment at fixed locations may fail to detect the presence of asbestos fibers. Due to limited air movement, many fibers may settle out of the air onto the floor and other surfaces and may not be captured on the filter. In the past, an 8-hour sampling period was recommended to cover various air circulation conditions. A quicker and more effective way to capture asbestos fibers is to circulate the air artificially so that the fibers remain airborne during sampling. The results from this sampling option typifies worst case condition. This is referred to as aggressive air sampling for asbestos. Refer to Table 2 for sample station locations.

1. Before starting the sampling pumps, direct forced air (such as a 1-horsepower leaf blower or large fan) against walls, ceilings, floors, ledges, and other surfaces in the room to initially dislodge fibers from surfaces. This should take at least 5 minutes per 1000 sq. ft. of floor.

2. Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.

3. Follow procedures in Section 7.4.1 and 7.4.2 (Turn off the pump and then the fan(s) when sampling is complete.).

4. Follow handling procedures in Section 3.2, steps 1-4.

8.0 CALCULATIONS

The sample volume is calculated from the average flow rate of the pump multiplied by the number of minutes the pump was running (volume = flow rate X time in minutes). The sample volume should be submitted to the laboratory and identified on the chain of custody for each sample (zero for lot, field and trip blanks).

The concentration result is calculated using the sample volume and the numbers of asbestos structures reported after the application of the cluster and matrix counting criteria.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Follow all QA/QC requirements from the laboratories as well as the analytical methods.

9.1 TEM Requirements

1. Examine lot blanks to determine the background asbestos structure concentration.

2. Examine field blanks to determine whether there is contamination by extraneous asbestos structures during specimen preparation.

3. Examine of laboratory blanks to determine if contamination is being introduced during critical phases of the laboratory program.

4. To determine if the laboratory can satisfactorily analyze samples of known asbestos structure concentrations, reference filters shall be examined. Reference filters should be maintained as part of the laboratory's Quality Assurance program.

5. To minimize subjective effects, some specimens should be recounted by a different microscopist.

6. Asbestos laboratories shall be accredited by the National Voluntary Laboratory Accreditation Program.

7. At this time, performance evaluation samples for asbestos in air are not available for Removal Program Activities.

9.2 PCM Requirements

1. Examine reference slides of known concentration to determine the analyst's ability to satisfactorily count fibers. Reference slides should be maintained as part of the laboratory's quality assurance program.

2. Examine field blanks to determine if there is contamination by extraneous structures during sample handling.

3. Some samples should be relabeled then submitted for counting by the same analyst to determine possible bias by the analyst.

4. Participation in a proficiency testing program such as the AIHA-NIOSH proficiency analytical testing (PAT) program.

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety procedures. More specifically, when entering an unknown situation involving asbestos, a powered air purifying respirator (PAPR) (full face-piece) is necessary in conjunction with HEPA filter cartridges. See applicable regulations for action level, PEL, TLV, etc. If previous sampling indicates asbestos concentrations are below personal health and safety levels, then Level D personal protection is adequate.

12.0 REFERENCES

(1) Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air, Part 1: Method, EPA/540/2-90/005a, May 1990, and Part 2: Technical Background Document, EPA/540/2-90/005b, May 1990.

(2) Methodology for the Measurement of Airborne Asbestos by Electron Microscopy, EPA's Report No. 68-02-3266, 1984, G. Yamate, S.C. Agarwal, and R. D. Gibbons.

(3) National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Method. Third Edition. 1987.

(4) U.S. Environmental Protection Agency. Code of Federal Regulations 40 CFR 763. July 1, 1987. Code of Federal Regulations 40 CFR 763 Addendum. October 30, 1987.

(5) U.S. Environmental Protection Agency. Asbestos-Containing Materials in Schools; Final Rule and Notice. 52 FR 41826.

(6) Occupational Safety and Health Administration. Code of Federal Regulations 29 CFR 1910.1001. Washington, D.C. 1987.

APPENDIX A

Tables

TABLE 1. SAMPLE STATIONS FOR OUTDOOR SAMPLING		
Sample Station Location	Sample Numbers	Rationale
Upwind/Background[(1)]	Collect a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establishes background fiber levels.
Downwind	Deploy a minimum of 3 sampling stations in a 180 degree arc downwind from the source.	Indicates if asbestos is leaving the site.
Site Representative and/or Worst Case	Obtain one site representative sample which shows average condition on-site or obtain worst case sample (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

[(1)] More than one background station may be required if the asbestos originates from different sources.

APPENDIX A (Cont'd)

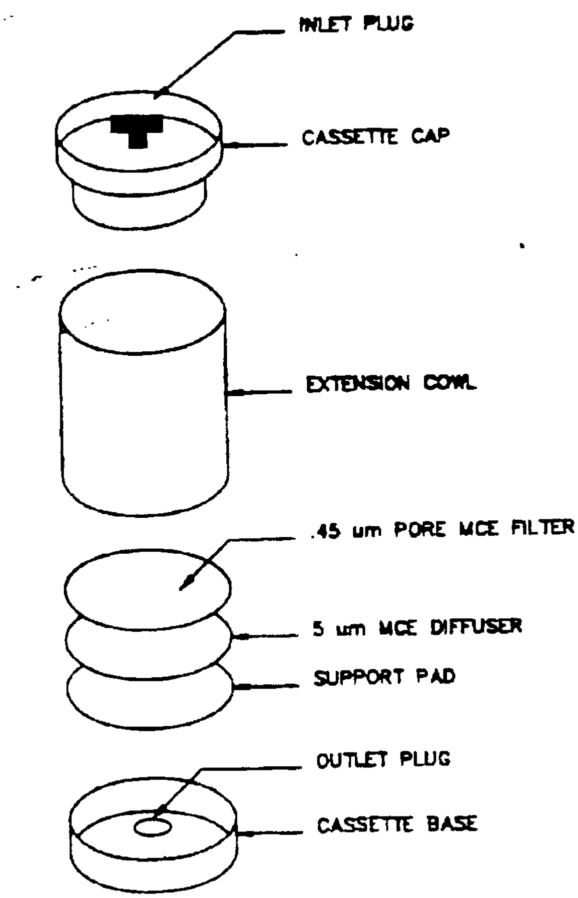
Tables

TABLE 2 SAMPLE STATIONS FOR INDOOR SAMPLING		
Sample Station Location	Sample Numbers	Rationale
Indoor Sampling	If a work site is a single room, disperse 5 samplers throughout the room. If the work site contains up to 5 rooms, place at least one sampler in each room. If the work site contains more than 5 rooms, select a representative sample of the rooms.	Establishes representative samples from a homogeneous area.
Upwind/Background	If outside sources are suspected, deploy a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establish whether indoor asbestos concentrations are coming from an outside source.
Worst Case	Obtain one worst case sample, i.e., aggressive sampling (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

APPENDIX B

Figures

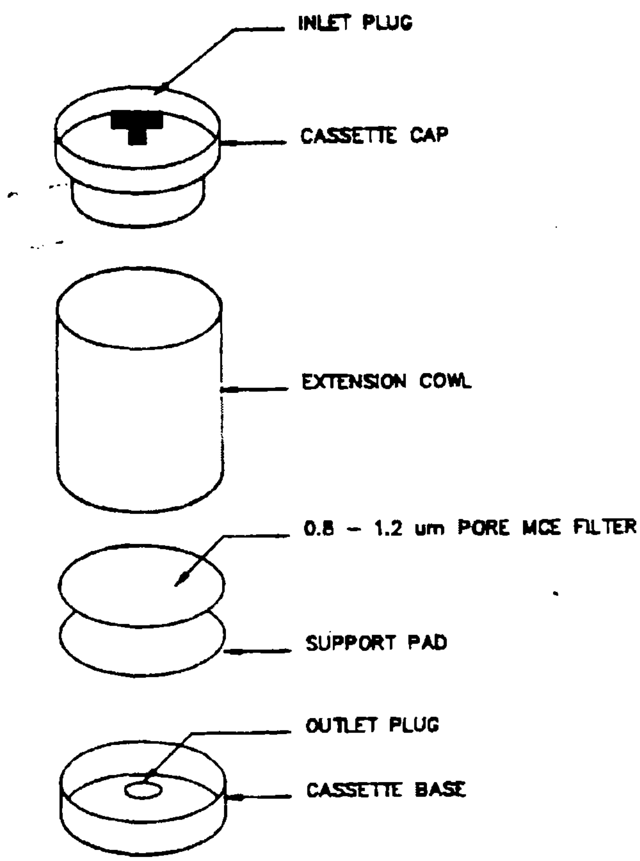
FIGURE 1. Transmission Electron Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

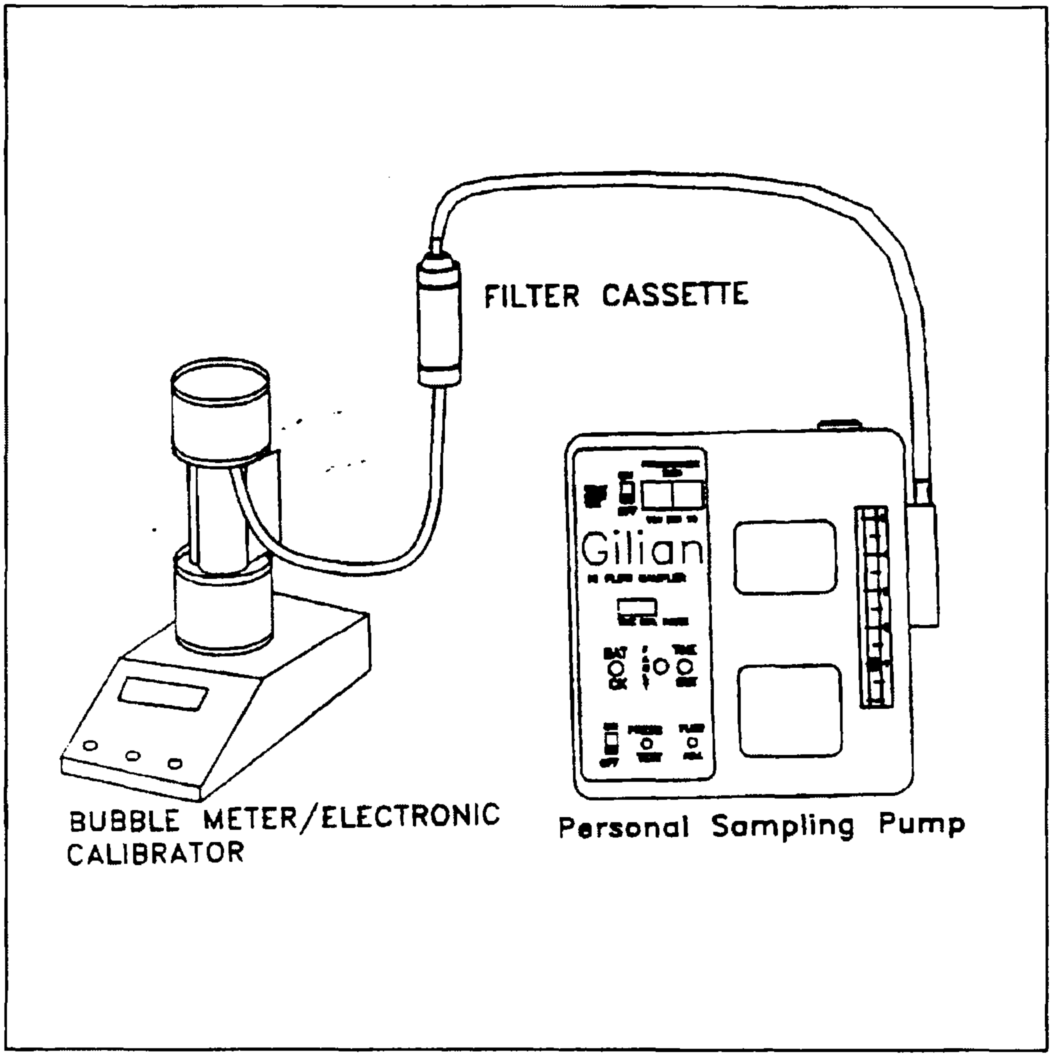
FIGURE 2. Phase Contrast Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

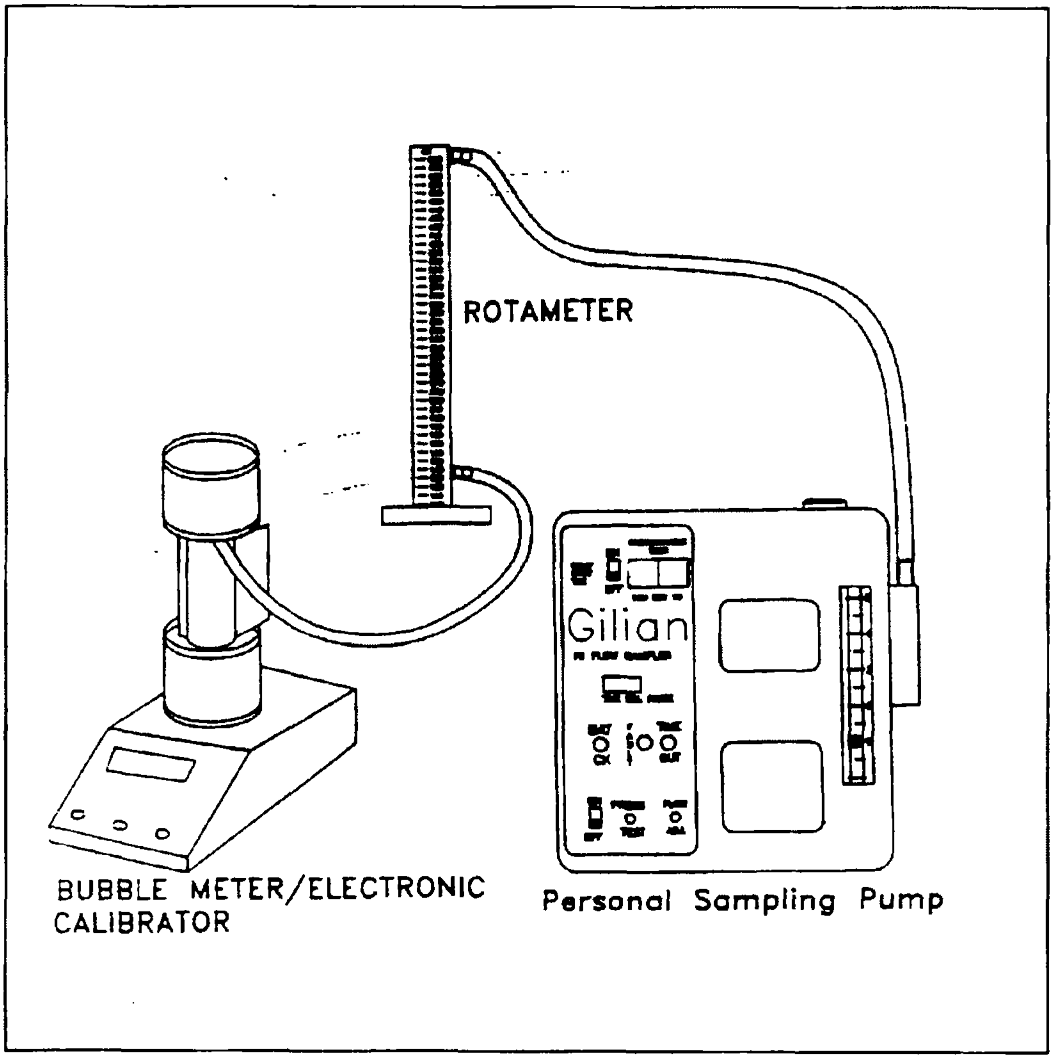
FIGURE 3. Calibrating a Personal Sampling Pump with a Bubble Meter



APPENDIX B (Cont'd)

Figures

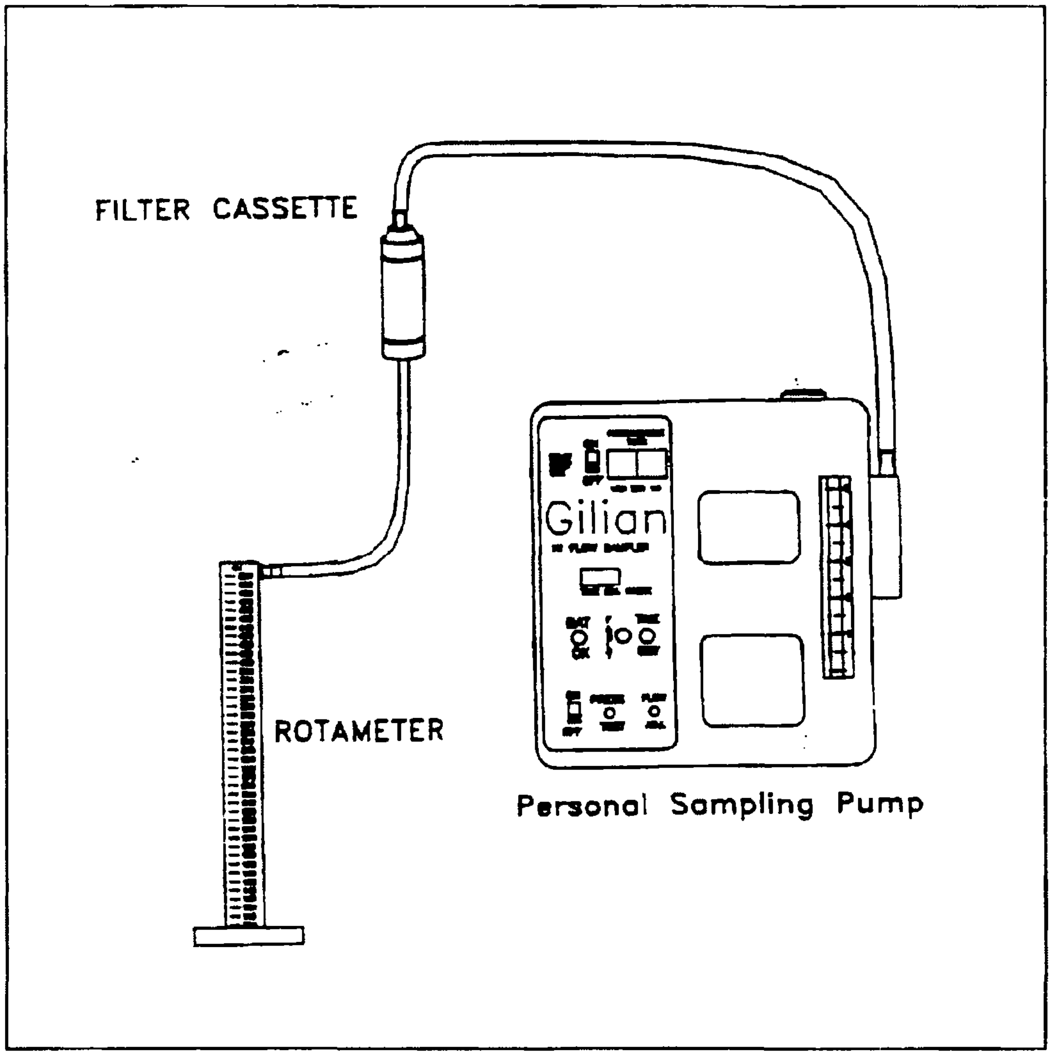
FIGURE 4. Calibrating a Rotameter with a Bubble Meter



APPENDIX B (Cont'd)

Figures

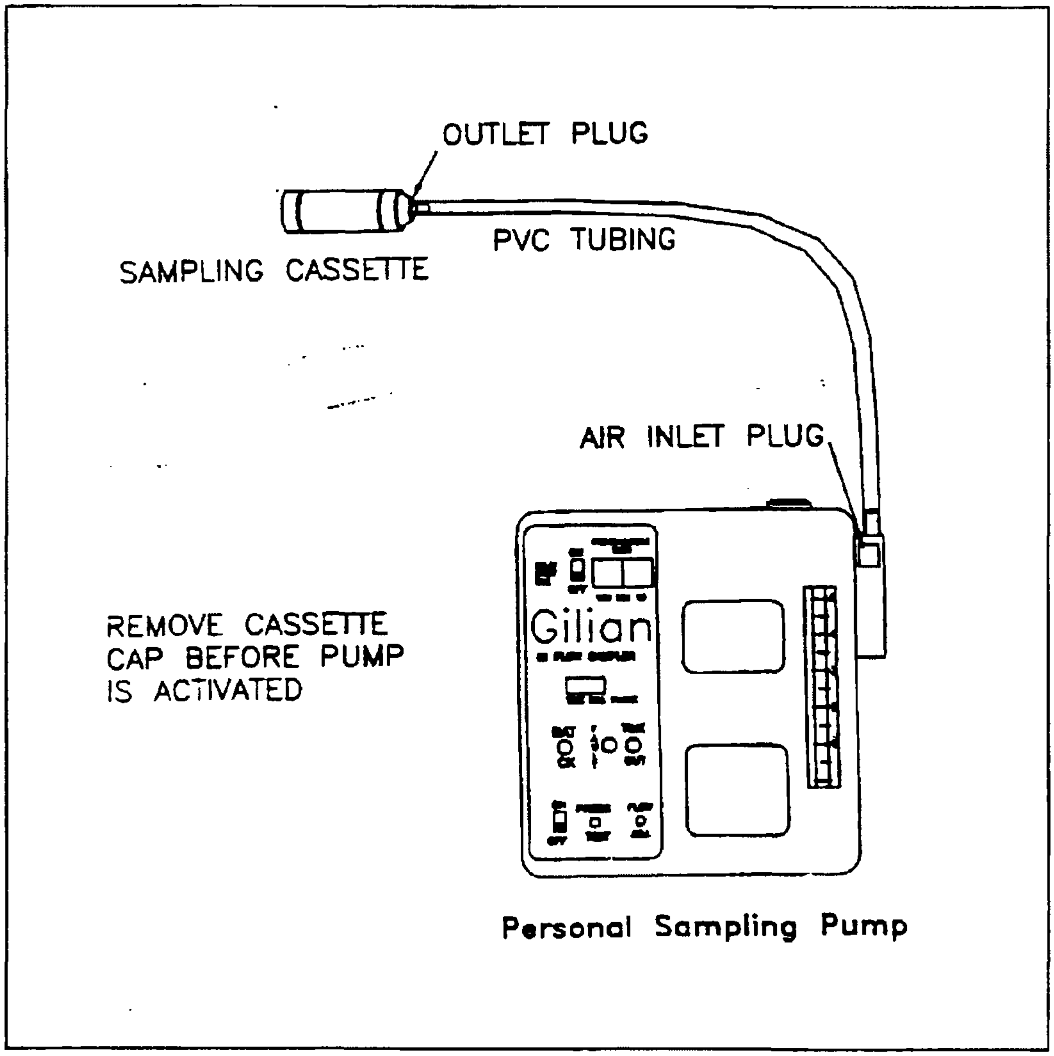
FIGURE 5. Calibrating a Sampling Pump with a Rotameter



APPENDIX B (Cont'd)

Figures

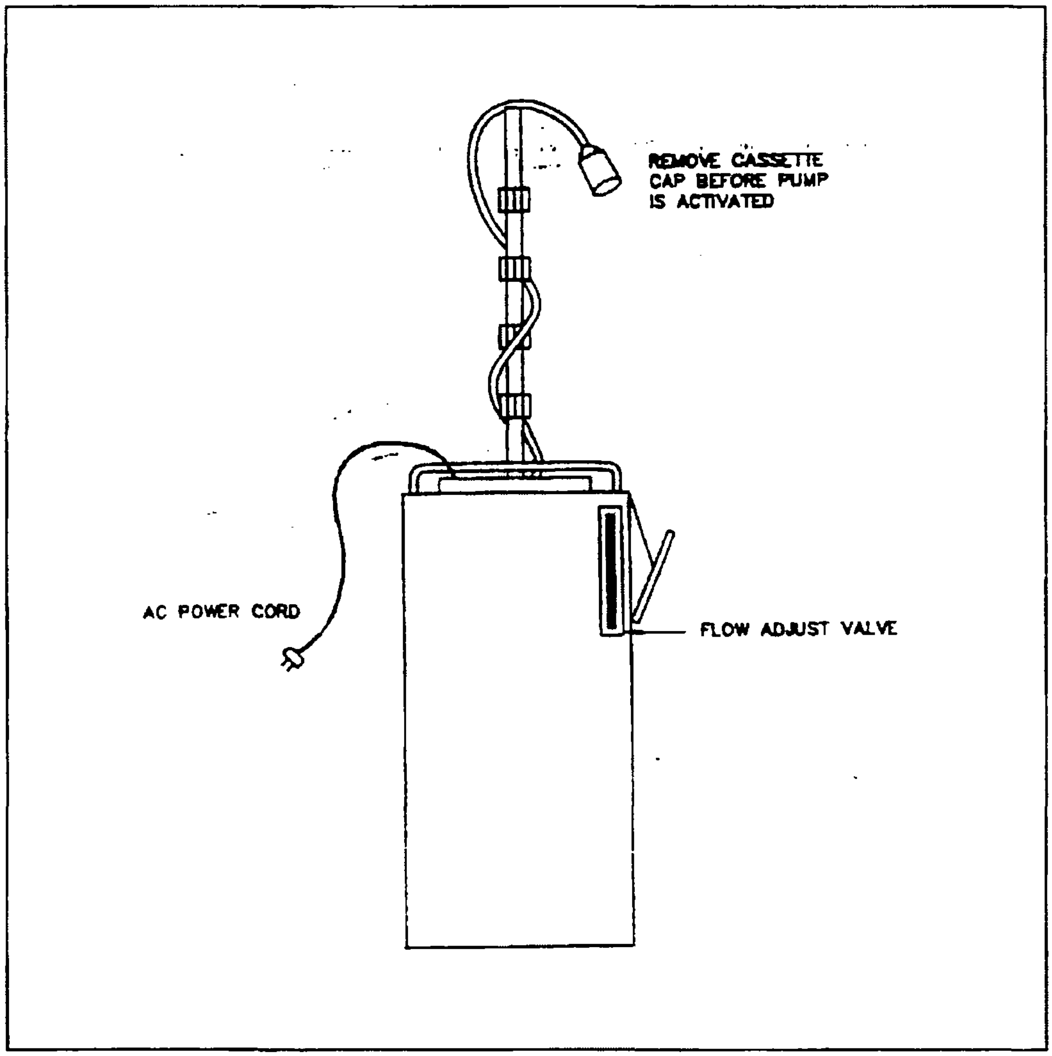
FIGURE 6. Personal Sampling Train for Asbestos



APPENDIX B (Cont'd)

Figures

FIGURE 7. High Flow Sampling Train for Asbestos



Project-Specific Guidance
Completion of Field Sample Data Sheets (FSDS)

Project: Libby Asbestos Project – Response Action

Project No.: 2603-024

Document No.: CDM-LIBBY-03 Revision 2

Prepared by: Terry Crowell Date: 11/17/03

Approved by: ______________________
Project Manager Date

____
Technical Reviewer Date

____
QA Reviewer Date

____
EPA Approval Date

A field sample data sheet (FSDS) must be completed using the following guidance.

Definitions:

eLASTIC – Electronic Libby Asbestos Sample Tracking Information Center. The onsite Libby property and sample tracking database maintained by CDM.

Owner – (As it appears in eLASTIC). Person who owns a residential property (may or may not be the current occupant), or the person who owns a commercial property.

Sample Coordinator – person responsible for the custody of all field paper work and samples collected.

Field Sample Data Sheet - All Media

Sheet No.: Pre-assigned unique sequential sheet number. Completed by sample coordinator.

Field Logbook No.: The logbook number being used to record information specific to the samples on the FSDS.

Page No.: Page number in logbook on which information regarding the samples on the FSDS is recorded.

Sampling Date: Date samples are collected, in the form DD/MM/YY.

Address: (As it appears in eLASTIC). The address of the property being sampled. Addresses are to be entered in the following format:

Street number - Direction - Street Name - Street Abbreviation

Where:
Street number = the number of the street address
Direction = the abbreviation of the street direction (N., S., E., or W.), when applicable. Periods are to be used after the street direction abbreviation. This rule does not apply to directions that follow the street name, such as Highway 37 North or Highway 2 West or South.
Street name = correct spelling of the street name
Street abbreviation = when applicable

Examples:
Road - Rd
Avenue - Ave
Extension - Ext
Street - St
Circle - Cr
Place - Pl
Boulevard - Blvd

Examples:
510 N. Mineral Ave
607 E. Cedar St Ext
521 Pipe Creek Rd
2800 Highway 37 North
300 Highway 2 South

Business Name: (As it appears in eLASTIC). If a business is located on the property, record the name. If a business is not located on the property, record NA.

Owner: (As it appears in eLASTIC). Name of the property owner (not necessarily the current occupant).

Land Use: Description of land use on which property is located.

Sampling Team: Company affiliation of sampling team.

Names: Full name of all members of the sampling team.

Index ID: Sample identification (ID) number. Index ID numbers for the response action samples are in the form 2R-#####. A set of available numbers is assigned to each sampling team by the sample coordinator.

Location ID: Unique identification number assigned to each sample location with a unique global positioning system (GPS) coordinate. A set of available numbers is assigned to each sampling team by the sample coordinator. For soil samples, location identifications (IDs) are in the form SP-######. For personal or stationary (including clearance) air monitoring samples, location IDs are in the form of AD-###### or BD-###### are assigned to each sampling team by the sample coordinator, where:

AD-###### is a unique number assigned to an address or work area.
BD-###### is a unique number assigned to a building or structure

In the case of lot blanks, AD-000001 is used for the location ID. In the case of field blanks, the AD number of the property where the cassette is opened is used. In the case of exposure monitoring or any other task where sampling is conducted at multiple properties, MA-000001 is used. Location IDs are tracked in the eLASTIC database, which should be used for reference whenever possible.

Sample Group: The sample group for response action samples must be one of the following options:

Alley	Driveway	Garden	Road
Attic	Exposure Monitoring	House	Shed
Barn	Field	Mine	Stockpile
Borrow Source	Flower Pots	Park	Vehicle
Basement	Flowerbed	Parking Lot	Walkway
Blank	Former Flowerbed	Play Area	Yard
Building	Former Garden	Property	
Crawl Space	Garage	Pumphouse	

Location Description: Description of the location where a sample was collected. Examples are: back yard, side yard, driveway, etc. for soil samples; basement, ground floor, second floor, etc. for air samples. If a soil sample is composed of sub-samples collected from more than one location, circle all that apply.

Category: FS = field sample; FB = field blank; LB = lot blank. Circle the applicable response.

The following sections provide instructions for recording media-specific information.

Field Sample Data Sheet - Soil

Matrix Type: Soil confirmation samples will usually be either surface or subsurface samples. If a sample collected is not a surface or subsurface sample, complete the "other" line using an applicable descriptor, such as mining waste, subsurface soil, fill, etc.

Type: Indicate the type of sample collected, grab or composite. If the sample is a composite sample, provide the number of sub-samples collected.

Time: The time of sample collection, in military time.

Top Depth: Top depth of sample, in inches below the ground surface.

Bottom Depth: Bottom depth of sample, in inches below the ground surface.

Field Comments: Any additional information specific to a sample, such as presence/absence of visible vermiculite.

QC (Field Team): Initials of field team member that completes the quality control check of FSDS.

Entered (LFO): Initials of sample coordination team member that enters the applicable FSDS information into eLASTIC.

Entered: Completed by Volpe personnel at time of data entry.

Validated: Completed by Volpe personnel at time of data entry check.

Field Sample Data Sheet - Stationary Air

Matrix Type: Circle whether the air sample was collected indoors or outdoors.

Filter Diameter: Circle the applicable filter diameter. For response action air sampling, cassettes with a 25-millimeter filter diameter will be used.

Pore Size: Circle the applicable pore size. For response action air sampling, phase contrast microscopy (PCM) cassettes with a 0.8-micron pore size filter will be used.

Flow Meter Type: Circle the applicable flow meter used.

Pump ID Number: Record the identification number of the pump used to collect the air sample.

Flow Meter ID Number: Record the identification number of the flow meter used to collect the air sample.

Start and Stop Date: Record the date sampling occurred in the format DD-MM-YY.

Start Time: Record the starting time of each air sample aliquot, in military time.

Start Flow: Record the starting pump flow rate for the air sample colleted in Liters per minute (L/min).

Stop Time: Record the stopping time of each air sample aliquot, in military time.

Stop Flow: Record the stopping pump flow rate for the air sample colleted in Liters per minute (L/min).

Pump Fault: If the pump faulted during air sample collection, circle Yes. If the pump did not fault during sample collection, circle No.

MET Station onsite: Circle the applicable response, Yes, No, or Not Applicable (NA). For all blanks (lot or field), circle NA.

Sample Type: Circle the applicable response. For the response action stationary air sampling, select one of the following:

Clear - first clearance sampling event
2nd Clear - second clearance sampling event
3rd Clear - third clearance sampling event
NA - used for all blanks

Cassette Lot Number: For lot blanks, the number identifying the lot the cassettes came from in the manufacturing process.

Field Sample Data Sheet - Personal Air

Person Sampled: First and last name of worker being monitored.

SSN: The last 4 digits of the Social Security Number of the worker being monitored.

Task: A brief description of the task being performed by the worker being monitored. Some examples are: vermiculite-containing insulation (VCI) removal, laborer, detail cleaning.

Matrix Type: Circle whether the air sample was collected indoors or outdoors.

Filter Diameter: Circle the applicable filter diameter. For response action air sampling, cassettes with a 25-millimeter filter diameter will be used.

Pore Size: Circle the applicable pore size. For response action air sampling, phase contrast microscopy (PCM) cassettes with a 0.8-micron pore size filter will be used.

Flow Meter Type: Circle the applicable flow meter used.

Pump ID Number: Record the identification number of the pump used to collect the air sample.

Flow Meter ID Number: Record the identification number of the flow meter used to collect the air sample.

Start and Stop Date: Record the date sampling occurred in the format DD-MM-YY.

Start Time: Record the starting time of each air sample aliquot, in military time.

Start Flow: Record the starting pump flow rate for the air sample colleted in Liters per minute (L/min).

Stop Time: Record the stopping time of each air sample aliquot, in military time.

Stop Flow: Record the stopping pump flow rate for the air sample colleted in Liters per minute (L/min).

Pump Fault: If the pump faulted during sample collection, circle Yes. If the pump did not fault during sample collection, circle No.

MET Station onsite: Circle the applicable response, Yes, No, or Not Applicable (NA). For all blanks (lot or field), circle NA.

Sample Type: Circle the applicable response. For the response action personal air sampling, select one of the following:

TWA - a time-weighted average sample, collected over an 8-hour period or used in conjunction with one or more other personal air samples to constitute monitoring over an average work day

EXC - an excursion sample, collected over a 30-minute period (time may be approximate)

NA - used for all blanks

Cassette Lot Number: For lot blanks, the number identifying the lot the cassettes came from in the manufacturing process.

Appendix B
Analytical Methods

NIOSH 7400 - Asbestos and Other Fibers by PCM

NIOSH 7402 - Asbestos by TEM

NIOSH 9002 - Asbestos (bulk) by PLM

AHERA - Appendix A to Subpart E of Part 763, Interim Transmission Electron Microscopy Analytical Methods - Mandatory and Nonmandatory - and Mandatory Section to Determine Completion of Response Actions

ASBESTOS and OTHER FIBERS by PCM 7400

Various MW: Various CAS: Various RTECS: Various

METHOD: 7400, Issue 2	**EVALUATION: FULL**	**Issue 1: Rev. 3 on 15 May 1989** **Issue 2: 15 August 1994**

OSHA : 0.1 asbestos fiber (> 5 µm long)/cc; 1 f/cc/30 min excursion; carcinogen
MSHA: 2 asbestos fibers/cc
NIOSH: 0.1 f/cc (fibers > 5 µm long)/400 L; carcinogen
ACGIH: 0.2 crocidolite; 0.5 amosite; 2 chrysotile and other asbestos, fibers/cc; carcinogen

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite [77536-66-4] or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole asbestos [1332-21-4]; refractory ceramic fibers [142844-00-6]; fibrous glass.

SAMPLING

SAMPLER:	FILTER (0.45- to 1.2-µm cellulose ester membrane, 25-mm; conductive cowl on cassette)
FLOW RATE*:	0.5 to 16 L/min
VOL-MIN*: **-MAX*:**	400 L @ 0.1 fiber/cc (step 4, sampling) *Adjust to give 100 to 1300 fiber/mm^2
SHIPMENT:	routine (pack to reduce shock)
SAMPLE STABILITY:	stable
BLANKS:	2 to 10 field blanks per set

ACCURACY

RANGE STUDIED:	80 to 100 fibers counted
BIAS:	See EVALUATION OF METHOD
OVERALL PRECISION (S_{rT}):	0.115 to 0.13 [1]
ACCURACY:	See EVALUATION OF METHOD

MEASUREMENT

TECHNIQUE:	LIGHT MICROSCOPY, PHASE CONTRAST
ANALYTE:	fibers (manual count)
SAMPLE PREPARATION:	acetone - collapse/triacetin - immersion
COUNTING RULES:	described in previous version of this method as "A" rules [1,3]
EQUIPMENT:	1. positive phase-contrast microscope 2. Walton-Beckett graticule (100-µm field of view) Type G-22 3. phase-shift test slide (HSE/NPL)
CALIBRATION:	HSE/NPL test slide
RANGE:	100 to 1300 fibers/mm^2 filter area
ESTIMATED LOD:	7 fibers/mm^2 filter area
PRECISION (S_r):	0.10 to 0.12 [1]; see EVALUATION OF METHOD

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. The method gives an index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fibers. Use this method in conjunction with electron microscopy (e.g., Method 7402) for assistance in identification of fibers. Fibers < ca. 0.25 µm diameter will not be detected by this method [4]. This method may be used for other materials such as fibrous glass by using alternate counting rules (see Appendix C).

INTERFERENCES: If the method is used to detect a specific type of fiber, any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chain-like particles may appear fibrous. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

OTHER METHODS: This revision replaces Method 7400, Revision #3 (date 5/15/89).

REAGENTS:

1. Acetone,* reagent grade.
2. Triacetin (glycerol triacetate), reagent grade.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically conductive extension cowl and cellulose ester filter, 0.45- to 1.2-µm pore size, and backup pad.
   - NOTE 1: Analyze representative filters for fiber background before use to check for clarity and background. Discard the filter lot if mean is ≥5 fibers per 100 graticule fields. These are defined as laboratory blanks. Manufacturer-provided quality assurance checks on filter blanks are normally adequate as long as field blanks are analyzed as described below.
   - NOTE 2: The electrically conductive extension cowl reduces electrostatic effects. Ground the cowl when possible during sampling.
   - NOTE 3: Use 0.8-µm pore size filters for personal sampling. The 0.45-µm filters are recommended for sampling when performing TEM analysis on the same samples. However, their higher pressure drop precludes their use with personal sampling pumps.
   - NOTE 4: Other cassettes have been proposed that exhibit improved uniformity of fiber deposit on the filter surface, e.g., bellmouthed sampler (Envirometrics, Charleston, SC). These may be used if shown to give measured concentrations equivalent to sampler indicated above for the application.
2. Personal sampling pump, battery or line-powered vacuum, of sufficient capacity to meet flow-rate requirements (see step 4 for flow rate), with flexible connecting tubing.
3. Wire, multi-stranded, 22-gauge; 1", hose clamp to attach wire to cassette.
4. Tape, shrink- or adhesive-.
5. Slides, glass, frosted-end, pre-cleaned, 25 x 75-mm.
6. Cover slips, 22- x 22-mm, No. 1-1/2, unless otherwise specified by microscope manufacturer.
7. Lacquer or nail polish.
8. Knife, #10 surgical steel, curved blade.
9. Tweezers.

EQUIPMENT:

10. Acetone flash vaporization system for clearing filters on glass slides (see ref. [5] for specifications or see manufacturer's instructions for equivalent devices).
11. Micropipets or syringes, 5-□L and 100- to 500-□L.
12. Microscope, positive phase (dark) contrast, with green or blue filter, adjustable field iris, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca. 400X); numerical aperture = 0.65 to 0.75.
13. Graticule, Walton-Beckett type with 100-µm diameter circular field (area = 0.00785 mm2) at the specimen plane (Type G-22). Available from Optometrics USA, P.O. Box 699, Ayer, MA 01432 [phone (508)-772-1700], and McCrone Accessories and Components, 850 Pasquinelli Drive, Westmont, IL 60559 [phone (312) 887-7100].
    NOTE: The graticule is custom-made for each microscope. (see APPENDIX A for the custom-ordering procedure).
14. HSE/NPL phase contrast test slide, Mark II. Available from Optometrics USA (address above).
15. Telescope, ocular phase-ring centering.
16. Stage micrometer (0.01-mm divisions).

SPECIAL PRECAUTIONS: Acetone is extremely flammable. Take precautions not to ignite it. Heating of acetone in volumes greater than 1 mL must be done in a ventilated laboratory fume hood using a flameless, spark- free heat source.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. To reduce contamination and to hold the cassette tightly together, seal the crease between the cassette base and the cowl with a shrink band or light colored adhesive tape. For personal sampling, fasten the (uncapped) open-face cassette to the worker's lapel. The open face should be oriented downward.
   NOTE: The cowl should be electrically grounded during area sampling, especially under conditions of low relative humidity. Use a hose clamp to secure one end of the wire (Equipment, Item 3) to the monitor's cowl. Connect the other end to an earth ground (i.e., cold water pipe).
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Handle field blanks in a manner representative of actual handling of associated samples in the set. Open field blank cassettes at the same time as other cassettes just prior to sampling. Store top covers and cassettes in a clean area (e.g., a closed bag or box) with the top covers from the sampling cassettes during the sampling period.
4. Sample at 0.5 L/min or greater [6]. Adjust sampling flow rate, Q (L/min), and time, t (min), to produce a fiber density, E, of 100 to 1300 fibers/mm^2 ($3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area A_c= 385 mm^2) for optimum accuracy. These variables are related to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \cdot E}{Q \cdot L \cdot 10^3}, \text{ min.}$$

NOTE 1: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. The collection efficiency does not appear to be a function of flow rate in the range of 0.5 to 16 L/min for asbestos fibers [7]. Relatively large diameter fibers (>3 µm) may exhibit significant aspiration loss and inlet deposition. A sampling rate of 1 to 4 L/min for 8 h is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If ≥ 50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration.

NOTE 2: OSHA regulations specify a minimum sampling volume of 48 L for an excursion measurement, and a maximum sampling rate of 2.5 L/min [3].

5. At the end of sampling, replace top cover and end plugs.
6. Ship samples with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.

   NOTE: Do not use untreated polystyrene foam in shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

NOTE 1: The object is to produce samples with a smooth (non-grainy) background in a medium with refractive index ≤1.46. This method collapses the filter for easier focusing and produces permanent (1 - 10 years) mounts which are useful for quality control and interlaboratory comparison. The aluminum "hot block" or similar flash vaporization techniques may be used outside the laboratory [2]. Other mounting techniques meeting the above criteria may also be used (e.g., the laboratory fume hood procedure for generating acetone vapor as described in Method 7400 - revision of 5/15/85, or the non-permanent field mounting technique used in P&CAM 239 [3,7,8,9]). Unless the effective filtration area is known, determine the area and record the information referenced against the sample ID number [1,9,10,11].

NOTE 2: Excessive water in the acetone may slow the clearing of the filter, causing material to be washed off the surface of the filter. Also, filters that have been exposed to high humidities prior to clearing may have a grainy background.

7. Ensure that the glass slides and cover slips are free of dust and fibers.
8. Adjust the rheostat to heat the "hot block" to ca. 70 °C [2].

   NOTE: If the "hot block" is not used in a fume hood, it must rest on a ceramic plate and be isolated from any surface susceptible to heat damage.
9. Mount a wedge cut from the sample filter on a clean glass slide.
   a. Cut wedges of ca. 25% of the filter area with a curved-blade surgical steel knife using a rocking motion to prevent tearing. Place wedge, dust side up, on slide.

      NOTE: Static electricity will usually keep the wedge on the slide.

b. Insert slide with wedge into the receiving slot at base of "hot block". Immediately place tip of a micropipet containing ca. 250 µL acetone (use the minimum volume needed to consistently clear the filter sections) into the inlet port of the PTFE cap on top of the "hot block" and inject the acetone into the vaporization chamber with a slow, steady pressure on the plunger button while holding pipet firmly in place. After waiting 3 to 5 sec for the filter to clear, remove pipet and slide from their ports.

CAUTION: Although the volume of acetone used is small, use safety precautions. Work in a well-ventilated area (e.g., laboratory fume hood). Take care not to ignite the acetone. Continuous use of this device in an unventilated space may produce explosive acetone vapor concentrations.

c. Using the 5-µL micropipet, immediately place 3.0 to 3.5 µL triacetin on the wedge. Gently lower a clean cover slip onto the wedge at a slight angle to reduce bubble formation. Avoid excess pressure and movement of the cover glass.

NOTE: If too many bubbles form or the amount of triacetin is insufficient, the cover slip may become detached within a few hours. If excessive triacetin remains at the edge of the filter under the cover slip, fiber migration may occur.

d. Mark the outline of the filter segment with a glass marking pen to aid in microscopic evaluation.

e. Glue the edges of the cover slip to the slide using lacquer or nail polish [12]. Counting may proceed immediately after clearing and mounting are completed.

NOTE: If clearing is slow, warm the slide on a hotplate (surface temperature 50 °C) for up to 15 min to hasten clearing. Heat carefully to prevent gas bubble formation.

CALIBRATION AND QUALITY CONTROL:

10. Microscope adjustments. Follow the manufacturers instructions. At least once daily use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric. With each microscope, keep a logbook in which to record the dates of microscope cleanings and major servicing.
    a. Each time a sample is examined, do the following:
        (1) Adjust the light source for even illumination across the field of view at the condenser iris. Use Kohler illumination, if available. With some microscopes, the illumination may have to be set up with bright field optics rather than phase contract optics.
        (2) Focus on the particulate material to be examined.
        (3) Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.
    b. Check the phase-shift detection limit of the microscope periodically for each analyst/microscope combination:
        (1) Center the HSE/NPL phase-contrast test slide under the phase objective.
        (2) Bring the blocks of grooved lines into focus in the graticule area.

        NOTE: The slide contains seven blocks of grooves (ca. 20 grooves per block) in descending order of visibility. For asbestos counting the microscope optics must completely resolve the grooved lines in block 3 although they may appear somewhat faint, and the grooved lines in blocks 6 and 7 must be invisible when centered in the graticule area. Blocks 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has resolution either too low or too high for fiber counting.

        (3) If image quality deteriorates, clean the microscope optics. If the problem persists, consult the microscope manufacturer.
11. Document the laboratory's precision for each counter for replicate fiber counts.
    a. Maintain as part of the laboratory quality assurance program a set of reference slides to be used on a daily basis [13]. These slides should consist of filter preparations including a range of loadings and background dust levels from a variety of sources including both field and reference samples (e.g., PAT, AAR, commercial samples). The Quality Assurance Officer

should maintain custody of the reference slides and should supply each counter with a minimum of one reference slide per workday. Change the labels on the reference slides periodically so that the counter does not become familiar with the samples.

b. From blind repeat counts on reference slides, estimate the laboratory intra- and intercounter precision. Obtain separate values of relative standard deviation (S_r) for each sample matrix analyzed in each of the following ranges: 5 to 20 fibers in 100 graticule fields, >20 to 50 fibers in 100 graticule fields, and >50 to 100 fibers in 100 graticule fields. Maintain control charts for each of these data files.

NOTE: Certain sample matrices (e.g., asbestos cement) have been shown to give poor precision [9]

12. Prepare and count field blanks along with the field samples. Report counts on each field blank.

NOTE 1: The identity of blank filters should be unknown to the counter until all counts have been completed.

NOTE 2: If a field blank yields greater than 7 fibers per 100 graticule fields, report possible contamination of the samples.

13. Perform blind recounts by the same counter on 10% of filters counted (slides relabeled by a person other than the counter). Use the following test to determine whether a pair of counts by the same counter on the same filter should be rejected because of possible bias: Discard the sample if the absolute value of the difference between the square roots of the two counts (in fiber/mm²) exceeds 2.77 (X)S_r', where X = average of the square roots of the two fiber counts

(in fiber/mm²) and $S_r' = \frac{S_r}{2}$, where S_r is the intracounter relative standard deviation for the

appropriate count range (in fibers) determined in step 11. For more complete discussions see reference [13].

NOTE 1: Since fiber counting is the measurement of randomly placed fibers which may be described by a Poisson distribution, a square root transformation of the fiber count data will result in approximately normally distributed data [13].

NOTE 2: If a pair of counts is rejected by this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts. It is not necessary to use this statistic on blank counts.

14. The analyst is a critical part of this analytical procedure. Care must be taken to provide a non-stressful and comfortable environment for fiber counting. An ergonomically designed chair should be used, with the microscope eyepiece situated at a comfortable height for viewing. External lighting should be set at a level similar to the illumination level in the microscope to reduce eye fatigue. In addition, counters should take 10-to-20 minute breaks from the microscope every one or two hours to limit fatigue [14]. During these breaks, both eye and upper back/neck exercises should be performed to relieve strain.

15. All laboratories engaged in asbestos counting should participate in a proficiency testing program such as the AIHA-NIOSH Proficiency Analytical Testing (PAT) Program for asbestos and routinely exchange field samples with other laboratories to compare performance of counters.

MEASUREMENT:

16. Center the slide on the stage of the calibrated microscope under the objective lens. Focus the microscope on the plane of the filter.

17. Adjust the microscope (Step 10).

NOTE: Calibration with the HSE/NPL test slide determines the minimum detectable fiber diameter (ca. 0.25 µm) [4].

18. Counting rules: (same as P&CAM 239 rules [1,10,11]: see examples in APPENDIX B).

a. Count any fiber longer than 5 µm which lies entirely within the graticule area.

(1) Count only fibers longer than 5 µm. Measure length of curved fibers along the curve.

(2) Count only fibers with a length-to-width ratio equal to or greater than 3:1.

b. For fibers which cross the boundary of the graticule field:

(1) Count as 1/2 fiber any fiber with only one end lying within the graticule area, provided that the fiber meets the criteria of rule a above.

(2) Do not count any fiber which crosses the graticule boundary more than once.
(3) Reject and do not count all other fibers.

c. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.
d. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 graticule fields regardless of count.

19. Start counting from the tip of the filter wedge and progress along a radial line to the outer edge. Shift up or down on the filter, and continue in the reverse direction. Select graticule fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. Ensure that, as a minimum, each analysis covers one radial line from the filter center to the outer edge of the filter. When an agglomerate or bubble covers ca. 1/6 or more of the graticule field, reject the graticule field and select another. Do not report rejected graticule fields in the total number counted.

NOTE 1: When counting a graticule field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count. A minimum counting time of 15 seconds per field is appropriate for accurate counting.

NOTE 2: This method does not allow for differentiation of fibers based on morphology. Although some experienced counters are capable of selectively counting only fibers which appear to be asbestiform, there is presently no accepted method for ensuring uniformity of judgment between laboratories. It is, therefore, incumbent upon all laboratories using this method to report total fiber counts. If serious contamination from non-asbestos fibers occurs in samples, other techniques such as transmission electron microscopy must be used to identify the asbestos fiber fraction present in the sample (see NIOSH Method 7402). In some cases (i.e., for fibers with diameters >1 m), polarized light microscopy (as in NIOSH Method 7403) may be used to identify and eliminate interfering non-crystalline fibers [15].

NOTE 3: Do not count at edges where filter was cut. Move in at least 1 mm from the edge.

NOTE 4: Under certain conditions, electrostatic charge may affect the sampling of fibers. These electrostatic effects are most likely to occur when the relative humidity is low (below 20%), and when sampling is performed near the source of aerosol. The result is that deposition of fibers on the filter is reduced, especially near the edge of the filter. If such a pattern is noted during fiber counting, choose fields as close to the center of the filter as possible [5].

NOTE 5: Counts are to be recorded on a data sheet that provides, as a minimum, spaces on which to record the counts for each field, filter identification number, analyst's name, date, total fibers counted, total fields counted, average count, fiber density, and commentary. Average count is calculated by dividing the total fiber count by the number of fields observed. Fiber density (fibers/mm^2) is defined as the average count (fibers/field) divided by the field (graticule) area (mm^2/field).

CALCULATIONS AND REPORTING OF RESULTS

20. Calculate and report fiber density on the filter, E (fibers/mm^2), by dividing the average fiber count per graticule field, F/n_f, minus the mean field blank count per graticule field, B/n_b, by the graticule field area, A_f (approx. 0.00785 mm^2):

$$E = \frac{\left(\frac{F}{n_f} - \frac{B}{n_b}\right)}{A_f}, \text{ fibers/mm}^2.$$

NOTE: Fiber counts above 1300 fibers/mm² and fiber counts from samples with >50% of filter area covered with particulate should be reported as "uncountable" or "probably biased." Other fiber counts outside the 100-1300 fiber/mm² range should be reported as having "greater than optimal variability" and as being "probably biased."

21. Calculate and report the concentration, C (fibers/cc), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (approx. 385 mm² for a 25-mm filter):

$$C = \frac{(E)(A_c)}{V \cdot 10^3}.$$

NOTE: Periodically check and adjust the value of A_c, if necessary.

22. Report intralaboratory and interlaboratory relative standard deviations (from Step 11) with each set of results.

NOTE: Precision depends on the total number of fibers counted [1,16]. Relative standard deviation is documented in references [1,15-17] for fiber counts up to 100 fibers in 100 graticule fields. Comparability of interlaboratory results is discussed below. As a first approximation, use 213% above and 49% below the count as the upper and lower confidence limits for fiber counts greater than 20 (Fig. 1).

EVALUATION OF METHOD:

A. This method is a revision of P&CAM 239 [10]. A summary of the revisions is as follows:
1. Sampling:
The change from a 37-mm to a 25-mm filter improves sensitivity for similar air volumes. The change in flow rates allows for 2-m³ full-shift samples to be taken, providing that the filter is not overloaded with non-fibrous particulates. The collection efficiency of the sampler is not a function of flow rate in the range 0.5 to 16 L/min [10].
2. Sample Preparation Technique:
The acetone vapor-triacetin preparation technique is a faster, more permanent mounting technique than the dimethyl phthalate/diethyl oxalate method of P&CAM 239 [2,4,10]. The aluminum "hot block" technique minimizes the amount of acetone needed to prepare each sample.
3. Measurement:
   a. The Walton-Beckett graticule standardizes the area observed [14,18,19].
   b. The HSE/NPL test slide standardizes microscope optics for sensitivity to fiber diameter [4,14].
   c. Because of past inaccuracies associated with low fiber counts, the minimum recommended loading has been increased to 100 fibers/mm² filter area (a total of 78.5 fibers counted in 100 fields, each with field area = .00785 mm².) Lower levels generally result in an overestimate of the fiber count when compared to results in the recommended analytical range [20]. The recommended loadings should yield intracounter S_r in the range of 0.10 to 0.17 [21,22,23].

B. Interlaboratory comparability:
An international collaborative study involved 16 laboratories using prepared slides from the asbestos cement, milling, mining, textile, and friction material industries [9]. The relative standard deviations (S_r) varied with sample type and laboratory. The ranges were:

	Intralaboratory S_r	Interlaboratory S_r	Overall S_r
AIA (NIOSH A Rules)*	0.12 to 0.40	0.27 to 0.85	0.46
Modified CRS (NIOSH B Rules)**	0.11 to 0.29	0.20 to 0.35	0.25

* Under AIA rules, only fibers having a diameter less than 3 m are counted and fibers attached to particles larger than 3 m are not counted. NIOSH A Rules are otherwise similar to the AIA rules.
** See Appendix C.

A NIOSH study conducted using field samples of asbestos gave intralaboratory S_r in the range 0.17 to 0.25 and an interlaboratory S_r of 0.45 [21]. This agrees well with other recent studies [9,14,16].

At this time, there is no independent means for assessing the overall accuracy of this method. One measure of reliability is to estimate how well the count for a single sample agrees with the mean count from a large number of laboratories. The following discussion indicates how this estimation can be carried out based on measurements of the interlaboratory variability, as well as showing how the results of this method relate to the theoretically attainable counting precision and to measured intra- and interlaboratory S_r. (NOTE: The following discussion does not include bias estimates and should not be taken to indicated that lightly loaded samples are as accurate as properly loaded ones).

Theoretically, the process of counting randomly (Poisson) distributed fibers on a filter surface will give an S_r that depends on the number, N, of fibers counted:

$$S_r = 1/(N)^{1/2} \tag{1}$$

Thus S_r is 0.1 for 100 fibers and 0.32 for 10 fibers counted. The actual S_r found in a number of studies is greater than these theoretical numbers [17,19,20,21].

An additional component of variability comes primarily from subjective interlaboratory differences. In a study of ten counters in a continuing sample exchange program, Ogden [15] found this subjective component of intralaboratory S_r to be approximately 0.2 and estimated the overall S_r by the term:

$$\frac{[\, N + (0.2 \cdot N)^2 \,]^{1/2}}{N} \tag{2}$$

Ogden found that the 90% confidence interval of the individual intralaboratory counts in relation to the means were +2 S_r and - 1.5 S_r. In this program, one sample out of ten was a quality control sample. For laboratories not engaged in an intensive quality assurance program, the subjective component of variability can be higher.

In a study of field sample results in 46 laboratories, the Asbestos Information Association also found that the variability had both a constant component and one that depended on the fiber count [14]. These results gave a subjective interlaboratory component of S_r (on the same basis as Ogden's) for field samples of ca. 0.45. A similar value was obtained for 12 laboratories analyzing a set of 24 field samples [21]. This value falls slightly above the range of S_r (0.25 to 0.42 for 1984-85) found for 80 reference laboratories in the NIOSH PAT program for laboratory-generated samples [17].

A number of factors influence S_r for a given laboratory, such as that laboratory's actual counting performance and the type of samples being analyzed. In the absence of other information, such as from an interlaboratory quality assurance program using field samples, the value for the subjective component of variability is chosen as 0.45. It is hoped that the laboratories will carry out the recommended interlaboratory quality assurance programs to improve their performance and thus reduce the S_r.

The above relative standard deviations apply when the population mean has been determined. It is more useful, however, for laboratories to estimate the 90% confidence interval on the mean count from a single sample fiber count (Figure 1). These curves assume similar shapes of the count distribution for interlaboratory and intralaboratory results [16].

For example, if a sample yields a count of 24 fibers, Figure 1 indicates that the mean interlaboratory count will fall within the range of 227% above and 52% below that value 90% of the time. We can apply these percentages directly to the air concentrations as well. If, for instance, this sample (24 fibers counted) represented a 500-L volume, then the measured concentration is 0.02 fibers/mL (assuming 100 fields counted, 25-mm filter, 0.00785 mm^2 counting field area). If this same sample were counted by a group of laboratories, there is a 90% probability that the mean would fall between 0.01 and 0.08 fiber/mL. These limits should be reported in any comparison of results between laboratories.

Note that the S_r of 0.45 used to derive Figure 1 is used as an estimate for a random group of laboratories. If several laboratories belonging to a quality assurance group can show that their interlaboratory S_r is smaller, then it is more correct to use that smaller S_r. However, the estimated S_r of 0.45 is to be used in the absence of such information. Note also that it has been found that S_r can be higher for certain types of samples, such as asbestos cement [9].

Quite often the estimated airborne concentration from an asbestos analysis is used to compare to a regulatory standard. For instance, if one is trying to show compliance with an 0.5 fiber/mL standard using a single sample on which 100 fibers have been counted, then Figure 1 indicates that the 0.5 fiber/mL standard must be 213% higher than the measured air concentration. This indicates that if one measures a fiber concentration of 0.16 fiber/mL (100 fibers counted), then the mean fiber count by a group of laboratories (of which the compliance laboratory might be one) has a 95% chance of being less than 0.5 fibers/mL; i.e., 0.16 + 2.13 x 0.16 = 0.5.

It can be seen from Figure 1 that the Poisson component of the variability is not very important unless the number of fibers counted is small. Therefore, a further approximation is to simply use +213% and −49% as the upper and lower confidence values of the mean for a 100-fiber count.

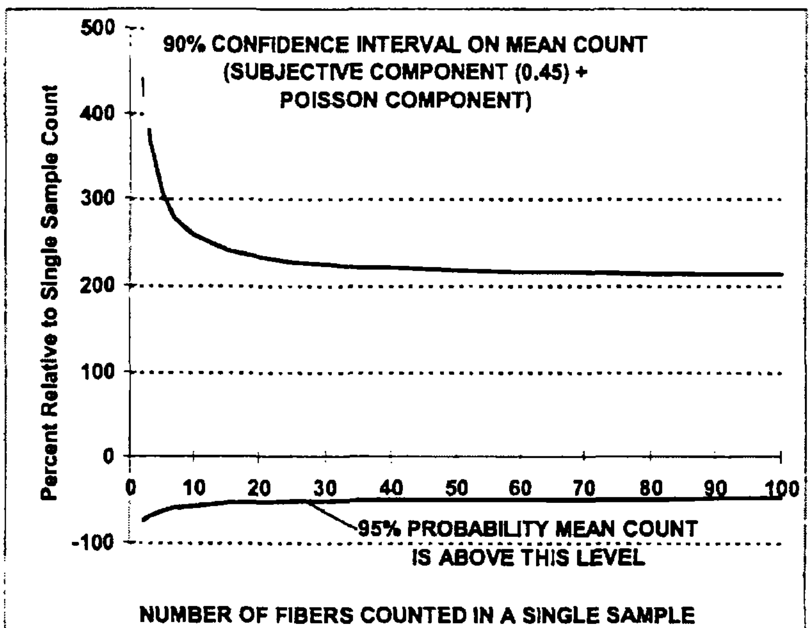


Figure 1. Interlaboratory Precision of Fiber Counts

The curves in Figures 1 are defined by the following equations:

$$UCL = \frac{2X + 2.25 + [(2.25 + 2X)^2 - 4(1 - 2.25 S_r^2) X^2]^{1/2}}{2(1 - 2.25 S_r^2)} \tag{3}$$

$$LCL = \frac{2X + 4 - [(4 + 2X)^2 - 4(1 - 4 S_r^2) X^2]^{1/2}}{2(1 - 4 S_r^2)} \tag{4}$$

where S_r = subjective interlaboratory relative standard deviation, which is close to the total interlaboratory S_r when approximately 100 fibers are counted.
X = total fibers counted on sample
LCL = lower 95% confidence limit.
UCL = upper 95% confidence limit.

Note that the range between these two limits represents 90% of the total range.

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APPENDIX A: CALIBRATION OF THE WALTON-BECKETT GRATICULE:

Before ordering the Walton-Beckett graticule, the following calibration must be done to obtain a counting area (D) 100 µm in diameter at the image plane. The diameter, d_c (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

1. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.
2. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.
3. Install the 40 to 45X phase objective.
4. Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.
5. Measure the magnified grid length of the graticule, L_o (µm), using the stage micrometer.
6. Remove the graticule from the microscope and measure its actual grid length, L_a (mm). This can best be accomplished by using a stage fitted with verniers.
7. Calculate the circle diameter, d_c (mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a}{L_o} \times D. \tag{5}$$

Example: If L_o = 112 □m, L_a = 4.5 mm and D = 100 □m, then d_c = 4.02 mm.

8. Check the field diameter, D (acceptable range 100 □m ± 2 □m) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (acceptable range 0.00754 mm^2 to 0.00817 mm^2).

APPENDIX B: COMPARISON OF COUNTING RULES:

Figure 2 shows a Walton-Beckett graticule as seen through the microscope. The rules will be discussed as they apply to the labeled objects in the figure.

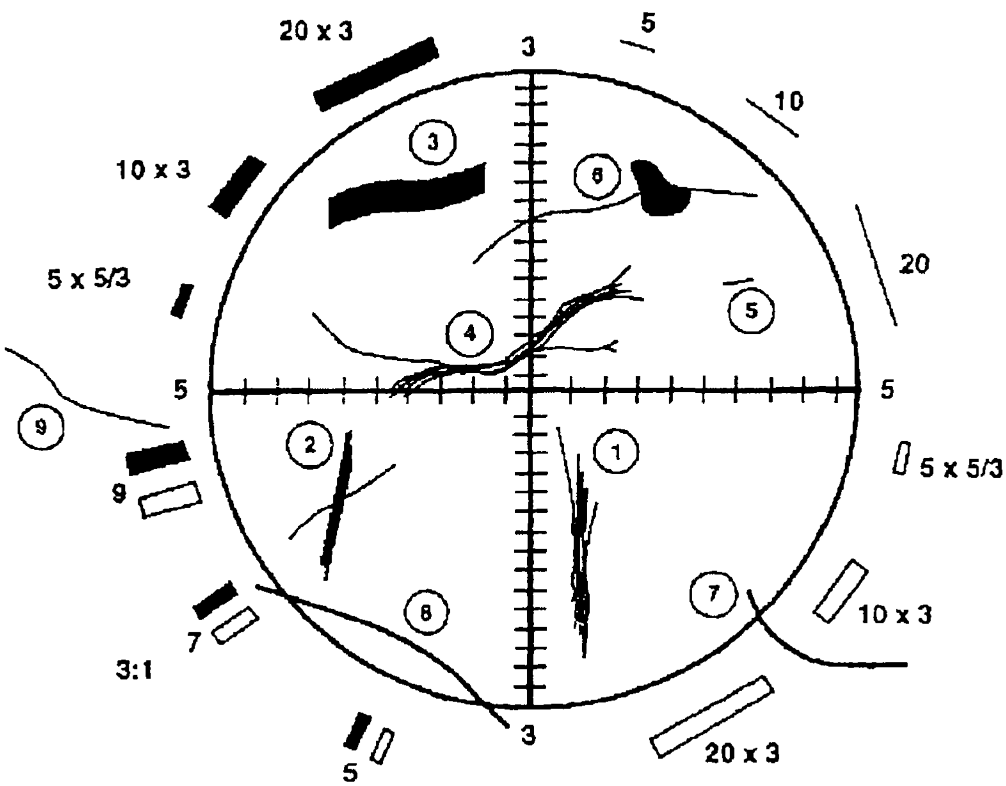

Figure 2. Walton-Beckett graticule with fibers.

These rules are sometimes referred to as the "A" rules.

FIBER COUNT

Object	Count	DISCUSSION
1	1 fiber	Optically observable asbestos fibers are actually bundles of fine fibrils. If the fibrils seem to be from the same bundle the object is counted as a single fiber. Note, however, that all objects meeting length and aspect ratio criteria are counted whether or not they appear to be asbestos.
2	2 fiber	If fibers meeting the length and aspect ratio criteria (length >5 µm and length-to-width ratio >3 to 1) overlap, but do not seem to be part of the same bundle, they are counted as separate fibers.
3	1 fiber	Although the object has a relatively large diameter (>3 µm), it is counted as fiber under the rules. There is no upper limit on the fiber diameter in the counting rules. Note that fiber width is measured at the widest compact section of the object.
4	1 fiber	Although long fine fibrils may extend from the body of a fiber, these fibrils are considered part of the fiber if they seem to have originally been part of the bundle.
5	Do not count	If the object is ≤5 µm long, it is not counted.
6	1 fiber	A fiber partially obscured by a particle is counted as one fiber. If the fiber ends emanating from a particle do not seem to be from the same fiber and each end meets the length and aspect ratio criteria, they are counted as separate fibers.
7	1/2 fiber	A fiber which crosses into the graticule area one time is counted as 1/2 fiber.
8	Do not count	Ignore fibers that cross the graticulate boundary more than once. count
9	Do not count	Ignore fibers that lie outside the graticule boundary.

APPENDIX C. ALTERNATE COUNTING RULES FOR NON-ASBESTOS FIBERS

Other counting rules may be more appropriate for measurement of specific non-asbestos fiber types, such as fibrous glass. These include the "B" rules given below (from NIOSH Method 7400, Revision #2, dated 8/15/87), the World Health Organization reference method for man-made mineral fiber [24], and the NIOSH fibrous glass criteria document method [25]. The upper diameter limit in these methods prevents measurements of non-thoracic fibers. It is important to note that the aspect ratio limits included in these methods vary. NIOSH recommends the use of the 3:1 aspect ratio in counting fibers.

It is emphasized that hybridization of different sets of counting rules is not permitted. Report specifically which set of counting rules are used with the analytical results.

"B" COUNTING RULES:

1. Count only <u>ends</u> of fibers. Each fiber must be longer than 5 μm and less than 3 μm diameter.
2. Count only ends of fibers with a length-to-width ratio equal to or greater than 5:1.
3. Count each fiber end which falls within the graticule area as one end, provided that the fiber meets rules 1 and 2 above. Add split ends to the count as appropriate if the split fiber segment also meets the criteria of rules 1 and 2 above.
4. Count visibly free ends which meet rules 1 and 2 above when the fiber appears to be attached to another particle, regardless of the size of the other particle. Count the end of a fiber obscured by another particle if the particle covering the fiber end is less than 3 μm in diameter.
5. Count free ends of fibers emanating from large clumps and bundles up to a maximum of 10 ends (5 fibers), provided that each segment meets rules 1 and 2 above.
6. Count enough graticule fields to yield 200 ends. Count a minimum of 20 graticule fields. Stop at 100 graticule fields, regardless of count.
7. Divide total end count by 2 to yield fiber count.

APPENDIX D. EQUIVALENT LIMITS OF DETECTION AND QUANTITATION

fiber density on filter*			fiber concentration in air, f/cc	
	fibers per 100 fields	fibers/mm²	400-L air sample	1000-L air sample
	200	255	0.25	0.10
	100	127	0.125	0.05
LOQ	80	102	0.10	0.04
	50	64	0.0625	0.025
	25	32	0.03	0.0125
	20	25	0.025	0.010
	10	12.7	0.0125	0.005
	8	10.2	0.010	0.004
LOD	5.5	7	0.00675	0.0027

* Assumes 385 mm² effective filter collection area, and field area = 0.00785 mm², for relatively "clean" (little particulate aside from fibers) filters.

ASBESTOS by TEM 7402

FORMULA: Various MW: Various CAS: Various RTECS: Various

METHOD: 7402 **EVALUATION: PARTIAL** **Issue 1: 15 May 1989**
Issue 2: 15 August 1994

OSHA : 0.1 asbestos fibers (>5 µm long)/cc; 1 f/cc/30 min excursion; carcinogen
MSHA: 2 asbestos fibers/cc
NIOSH: 0.1 f/cc (fibers > 5 µm long)/400 L; carcinogen
ACGIH: 0.2 crocidolite; 0.5 amosite; 2 chrysotile and other asbestos, fibers/cc; carcinogen

PROPERTIES: solid, fibrous, crystalline, anistropic

SYNONYMS [CAS#]: actinolite [77536-66-4] or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole asbestos [1332-21-4].

SAMPLING

SAMPLER: FILTER (0.45- to 1.2-µm cellulose ester membrane, 25-mm diameter; conductive cassette)

FLOW RATE: 0.5 to 16 L/min

VOL-MIN*: 400 L @ 0.1 fiber/cc
-MAX*: (step 4, sampling)
*Adjust for 100 to 1300 fibers/mm^2

SHIPMENT: routine (pack to reduce shock)

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 80 to 100 fibers counted

BIAS: not determined

OVERALL PRECISION ($\hat{S}_{rT}$): see EVALUATION OF METHOD

ACCURACY: not determined

MEASUREMENT

TECHNIQUE: MICROSCOPY, TRANSMISSION ELECTRON (TEM)

ANALYTE: asbestos fibers

SAMPLE PREPARATION: modified Jaffe wick

EQUIPMENT: transmission electron microscope; energy dispersive X-ray system (EDX) analyzer

CALIBRATION: qualitative electron diffraction; calibration of TEM magnification and EDX system

RANGE: 100 to 1300 fibers/mm^2 filter area [1]

ESTIMATED LOD: 1 confirmed asbestos fiber above 95% of expected mean blank value

PRECISION ($\hat{S}_r$): 0.28 when 65% of fibers are asbestos; 0.20 when adjusted fiber count is applied to PCM count [2].

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. This method is used to determine asbestos fibers in the optically visible range and is intended to complement the results obtained by phase contrast microscopy (Method 7400).

INTERFERENCES: Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fiber identification. Some non-asbestos amphibole minerals may give electron diffraction patterns similar to asbestos amphiboles.

OTHER METHODS: This method is designed for use with Method 7400 (phase contrast microscopy).

REAGENTS:

1. Acetone. (See SPECIAL PRECAUTIONS.)

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically-conductive extension cowl, cellulose ester membrane filter, 0.45- to 1.2-µm pore size, and backup pad.
   NOTE 1: Analyze representative filters for fiber background before use. Discard the filter lot if mean count is >5 fibers/100 fields. These are defined as laboratory blanks.
   NOTE 2: Use an electrically-conductive extension cowl to reduce electrostatic effects on fiber sampling and during sample shipment. Ground the cowl when possible during sampling.
   NOTE 3: 0.8-µm pore size filters are recommended for personal sampling. 0.45-µm filters are recommended for sampling when performing TEM analysis on the samples because the particles deposit closer to the filter surface. However, the higher pressure drop through these filters normally preclude their use with personal sampling pumps.
2. Personal sampling pump, 0.5 to 16 L/min, with flexible connecting tubing.
3. Microscope, transmission electron, operated at ca. 100 kV, with electron diffraction and energy-dispersive X-ray capabilities, and having a fluorescent screen with inscribed or overlaid calibrated scale (Step 15).
   NOTE: The scale is most efficient if it consists of a series of lines inscribed on the screen or partial circles every 2 cm distant from the center.
4. Diffraction grating replica with known number of lines/mm.
5. Slides, glass, pre-cleaned, 25- x 75-mm.
6. Knife, surgical steel, curved-blade.
7. Tweezers.
8. Grids, 200-mesh TEM copper, (optional: carbon-coated).
9. Petri dishes, 15-mm depth. The top and bottom of the petri dish must fit snugly together. To assure a tight fit, grind the top and bottom pieces together with an abrasive such as carborundum to produce a ground-glass contact surface.
10. Foam, clean polyurethane, spongy, 12-mm thick.
11. Filters, Whatman No. 1 qualitative paper or equivalent, or lens paper.
12. Vacuum evaporator.
13. Cork borer, (about 8-mm).
14. Pen, waterproof, marking.
15. Reinforcement, page, gummed.
16. Asbestos standard bulk materials for reference; e.g. SRM #1866, available from the National Institute of Standards and Technology.
17. Carbon rods, sharpened to 1 mm x 8 mm.
18. Microscope, light, phase contrast (PCM), with Walton-Beckett graticule (see method 7400).
19. Grounding wire, 22-gauge, multi-strand.
20. Tape, shrink- or adhesive-.

SPECIAL PRECAUTIONS: Acetone is extremely flammable (flash point = 0 °F). Take precautions not to ignite it. Heating of acetone must be done in a fume hood using a flameless, spark-free heat source. Asbestos is a confirmed human carcinogen. Handle only in a well-ventilated fume hood.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. For personal sampling, fasten sampler to worker's lapel near worker's mouth. Remove the top cover from cowl extension ("open-face") and orient sampler face down. Wrap joint between extender and monitor body with tape to help hold the cassette together and provide a marking surface to identify the cassette. Where possible, especially at low %RH, attach sampler to electrical ground to reduce electrostatic effects during sampling.
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Remove top covers from the field blank cassettes and store top covers and cassettes in a clean area (e.g., closed bag or box) during sampling. Replace top covers when sampling is completed.
4. Sample at 0.5 to 16 L/min [3]. Adjust sampling rate, Q (L/min), and time, t (min), to produce fiber density, E, of 100 to 1300 fibers/mm^2 [$3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area (A_c= 385 mm^2)] for optimum accuracy. Do not exceed ca. 0.5 mg total dust loading on the filter. These variables are related to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \cdot E}{Q \cdot L \cdot 10^3}, \text{ min.}$$

   NOTE: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. A sampling rate of 1 to 4 L/min for 8 h (700 to 2800 L) is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust [3].
5. At the end of sampling, replace top cover and small end caps.
6. Ship samples upright with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.
   NOTE: Do not use untreated polystyrene foam in the shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

7. Remove circular sections from any of three quadrants of each sample and blank filter using a cork borer [4]. The use of three grid preparations reduces the effect of local variations in dust deposit on the filter.
8. Affix the circular filter sections to a clean glass slide with a gummed page reinforcement. Label the slide with a waterproof marking pen.
   NOTE: Up to eight filter sections may be attached to the same slide.
9. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 min for the sample filter(s) to fuse and clear.
   NOTE: The "hot block" clearing technique [5] of Method 7400 or the DMF clearing technique [6] may be used instead of steps 8 and 9.
10. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1- by 5-mm section of a graphite rod onto the cleared filter(s). Remove the slide to a clean, dry, covered petri dish [4].
11. Prepare a second petri dish as a Jaffe wick washer with the wicking substrate prepared from filter or lens paper placed on top of a 12-mm thick disk of clean, spongy polyurethane foam [7].

Cut a V-notch on the edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent.

NOTE: The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

12. Place the TEM grid on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish halves and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated.

    NOTE: The level of acetone should be just high enough to saturate the filter paper without creating puddles.

13. Remove about a quarter section of the carbon-coated filter from the glass slide using a surgical knife and tweezers. Carefully place the excised filter, carbon side down, on the appropriately-labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to raise the acetone level as high as possible without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it (allowing drops of condensed acetone to form near the edge rather than in the center where they would drip onto the grid preparation).

CALIBRATION AND QUALITY CONTROL:

14. Determine the TEM magnification on the fluorescent screen:
    a. Define a field of view on the fluorescent screen either by markings or physical boundaries.
       NOTE: The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric) [7].
    b. Insert a diffraction grating replica into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that goniometer stage tilt is zero.
    c. Adjust microscope magnification to 10,000X. Measure the distance (mm) between the same relative positions (e.g., between left edges) of two widely-separated lines on the grating replica. Count the number of spaces between the lines.
       NOTE: On most microscopes the magnification is substantially constant only within the central 8- to 10-cm diameter region of the fluorescent screen.
    d. Calculate the true magnification (M) on the fluorescent screen:

$$m = \frac{X \cdot G}{Y}$$

       where: X = total distance (mm) between the two grating lines;
       G = calibration constant of the grating replica (lines/mm);
       Y = number of grating replica spaces counted
    e. After calibration, note the apparent sizes of 0.25 and 5.0 µm on the fluorescent screen. (These dimensions are the boundary limits for counting asbestos fibers by phase contrast microscopy.)

15. Measure 20 grid openings at random on a 200-mesh copper grid by placing a grid on a glass slide and examining it under the PCM. Use the Walton-Beckett graticule to measure the grid opening dimensions. Calculate an average graticule field dimension from the data and use this number to calculate the graticule field area for an average grid opening.

    NOTE: A grid opening is considered as one graticule field.

16. Obtain reference selected area electron diffraction (SAED) or microdiffraction patterns from standard asbestos materials prepared for TEM analysis.

    NOTE: This is a visual reference technique. No quantitative SAED analysis is required [7]. Microdiffraction may produce clearer patterns on very small fibers or fibers partially obscured by other material.

    a. Set the specimen holder at zero tilt.

b. Center a fiber, focus, and center the smallest field-limiting aperture on the fiber. Obtain a diffraction pattern. Photograph each distinctive pattern and keep the photo for comparison to unknowns.

NOTE: Not all fibers will present diffraction patterns. The objective lens current may need adjustment to give optimum pattern visibility. There are many more amphiboles which give diffraction patterns similar to the analytes named on p. 7402-1. Some, but not all, of these can be eliminated by chemical separations. Also, some non-amphiboles (e.g., pyroxenes, some talc fibers) may interfere.

17. Acquire energy-dispersive X-ray (EDX) spectra on approximately 5 fibers having diameters between 0.25 and 0.5 µm of each asbestos variety obtained from standard reference materials [7].

NOTE: The sample may require tilting to obtain adequate signal. Use same tilt angle for all spectra.

a. Prepare TEM grids of all asbestos varieties.
b. Use acquisition times (at least 100 sec) sufficient to show a silicon peak at least 75% of the monitor screen height at a vertical scale of ≥500 counts per channel.
c. Estimate the elemental peak heights visually as follows:
   (1) Normalize all peaks to silicon (assigned an arbitrary value of 10).
   (2) Visually interpret all other peaks present and assign values relative to the silicon peak.
   (3) Determine an elemental profile for the fiber using the elements Na, Mg, Si, Ca, and Fe. Example: 0-4-10-3-<1 [7].
   NOTE: In fibers other than asbestos, determination of Al, K, Ti, S, P, and F may also be required for fiber characterization.
   (4) Determine a typical range of profiles for each asbestos variety and record the profiles for comparison to unknowns.

MEASUREMENT:

18. Perform a diffraction pattern inspection on all sample fibers counted under the TEM, using the procedures given in step 17. Assign the diffraction pattern to one of the following structures:
a. chrysotile;
b. amphibole;
c. ambiguous;
d. none.

NOTE: There are some crystalline substances which exhibit diffraction patterns similar to those of asbestos fibers. Many of these, (brucite, halloysite, etc.) can be eliminated from consideration by chemistry. There are, however, several minerals (e.g., pyroxenes, massive amphiboles, and talc fibers) which are chemically similar to asbestos and can be considered interferences. The presence of these substances may warrant the use of more powerful diffraction pattern analysis before positive identification can be made. If interferences are suspected, morphology can play an important role in making positive identification.

19. Obtain EDX spectra in either the TEM or STEM modes from fibers on field samples using the procedure of step 18. Using the diffraction pattern and EDX spectrum, classify the fiber:
a. For a chrysotile structure, obtain EDX spectra on the first five fibers and one out of ten thereafter. Label the range profiles from 0-5-10-0-0 to 0-10-10-0-0 as "chrysotile."
b. For an amphibole structure, obtain EDX spectra on the first 10 fibers and one out of ten thereafter. Label profiles ca. 0-2-10-0-7 as "possible amosite"; profiles ca. 1-1-10-0-6 as "possible crocidolite"; profiles ca. 0-4-10-3-<1 as "possible tremolite"; and profiles ca. 0-3-10-0-1 as "possible anthophyllite."
   NOTE: The range of profiles for the amphiboles will vary up to ± 1 unit for each of the elements present according to the relative detector efficiency of the spectrometer.
c. For an ambiguous structure, obtain EDX spectra on all fibers. Label profiles similar to the chrysotile profile as "possible chrysotile." Label profiles similar to the various amphiboles as "possible amphiboles." Label all others as "unknown" or "non-asbestos."

20. Counting and Sizing:
   a. Insert the sample grid into the specimen grid holder and scan the grid at zero tilt at low magnification (ca. 300 to 500X). Ensure that the carbon film is intact and unbroken over ca. 75% of the grid openings.
   b. In order to determine how the grids should be sampled, estimate the number of fibers per grid opening during a low-magnification scan (500 to 1000X). This will allow the analyst to cover most of the area of the grids during the fiber count and analysis. Use the following rules when picking grid openings to count [7,8]:
      (1) Light loading (<5 fibers per grid opening): count total of 40 grid openings.
      (2) Moderate loading (5 to 25 fibers per grid opening): count minimum of 40 grid openings or 100 fibers.
      (3) Heavy loading (>25 fibers per opening): count a minimum of 100 fibers and at least 6 grid openings.

      Note that these grid openings should be selected approximately equally among the three grid preparations and as randomly as possible from each grid.
   c. Count only grid openings that have the carbon film intact. At 500 to 1000X magnification, begin counting at one end of the grid and systematically traverse the grid by rows, reversing direction at row ends. Select the number of fields per traverse based on the loading indicated in the initial scan. Count at least 2 field blanks per sample set to document possible contamination of the samples. Count fibers using the following rules:
      (1) Count all particles with diameter greater than 0.25 µm that meet the definition of a fiber (aspect ratio ≥3:1, longer than 5 µm). Use the guideline of counting all fibers that would have been counted under phase contrast light microscopy (Method 7400). Use higher magnification (10000X) to determine fiber dimensions and countability under the acceptance criteria. Analyze a minimum of 10% of the fibers, and at least 3 asbestos fibers, by EDX and SAED to confirm the presence of asbestos. Fibers of similar morphology under high magnification can be identified as asbestos without SAED. Particles which are of questionable morphology should be analyzed by SAED and EDX to aid in identification.
      (2) Count fibers which are partially obscured by the grid as half fibers.

         NOTE: If a fiber is partially obscured by the grid bar at the edge of the field of view, count it as a half fiber only if more than 2.5 µm of fiber is visible.
      (3) Size each fiber as it is counted and record the diameter and length:
         (a) Move the fiber to the center of the screen. Read the length of the fiber directly from the scale on the screen.

            NOTE 1: Data can be recorded directly off the screen in µm and later converted to µm by computer.

            NOTE 2: For fibers which extend beyond the field of view, the fiber must be moved and superimposed upon the scale until its entire length has been measured.
         (b) When a fiber has been sized, return to the lower magnification and continue the traverse of the grid area to the next fiber.
   d. Record the following fiber counts:
      (1) f_s, f_b = number of asbestos fibers in the grid openings analyzed on the sample filter and corresponding field blank, respectively.
      (2) F_s, F_b = number of fibers, regardless of identification, in the grid openings analyzed on the sample filter and corresponding field blank, respectively.

CALCULATIONS:

21. Calculate and report the fraction of optically visible asbestos fibers on the filter, $(f_s - f_b)/(F_s - F_b)$. Apply this fraction to fiber counts obtained by PCM on the same filter or on other filters for which the TEM sample is representative. The final result is an asbestos fiber count. The type of asbestos present should also be reported.
22. As an integral part of the report, give the model and manufacturer of the TEM as well as the model and manufacturer of the EDX system.

EVALUATION OF METHOD:

The TEM method, using the direct count of asbestos fibers, has been shown to have a precision of 0.275 (s_r) in an evaluation of mixed amosite and wollastonite fibers. The estimate of the asbestos fraction, however, had a precision of 0.11 (s_r). When this fraction was applied to the PCM count, the overall precision of the combined analysis was 0.20 [2].

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METHOD REVISED BY:

Paul A. Baron, Ph.D.; NIOSH/DPSE.

ASBESTOS (bulk) by PLM 9002

various MW: various CAS: 1332-21-4 RTECS: C16475000

METHOD: 9002, Issue 2	**EVALUATION: PARTIAL**	**Issue 1: 15 May 1989** **Issue 2: 15 August 1994**

EPA Standard (Bulk): 1%

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite [77536-66-4], or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole.

SAMPLING		MEASUREMENT	
BULK SAMPLE:	1 to 10 grams	**TECHNIQUE:**	MICROSCOPY, STEREO AND POLARIZED LIGHT, WITH DISPERSION STAINING
SHIPMENT:	seal securely to prevent escape of asbestos	**ANALYTE:**	actinolite asbestos, amosite, anthophyllite asbestos, chrysotile, crocidolite, tremolite asbestos
SAMPLE STABILITY:	stable	**EQUIPMENT:**	microscope, polarized light; 100-400X dispersion staining objective, stereo microscope: 10-45X
BLANKS:	none required	**RANGE:**	1% to 100% asbestos
ACCURACY		**ESTIMATED LOD:**	<1% asbestos [1]
RANGE STUDIED:	<1% to 100% asbestos	**PRECISION:**	not determined
BIAS:	not determined		
PRECISION:	not determined		
ACCURACY:	not determined		

APPLICABILITY: this method is useful for the qualitative identification of asbestos and the semi-quantitative determination of asbestos content of bulk samples. The method measures percent asbestos as perceived by the analyst in comparison to standard area projections, photos, and drawings, or trained experience. The method is not applicable to samples containing large amounts of fine fibers below the resolution of the light microscope

INTERFERENCES: Other fibers with optical properties similar to the asbestos minerals may give positive interferences. Optical properties of asbestos may be obscured by coating on the fibers. Fibers finer than the resolving power of the microscope (ca. 0.3 µm) will not be detected. Heat and acid treatment may alter the index of refraction of asbestos and change its color.

OTHER METHODS: This method (originally designated as method 7403) is designed for use with NIOSH Methods 7400 (phase contrast microscopy) and 7402 (electron microscopy/EDS). The method is similar to the EPA bulk asbestos method [1].

REAGENTS:

1. Refractive index (RI) liquids for Dispersion Staining: high-dispersion (HD) series, 1.550, 1.605, 1.620.
2. Refractive index liquids: 1.670, 1.680, and 1.700.
3. Asbestos reference samples such as SRM #1866, available from the National Institute of Standards and Technology.*
4. Distilled Water (optional).
5. Concentrated HCl: ACS reagent grade.

* See SPECIAL PRECAUTIONS

EQUIPMENT:

1. Sample containers: screw-top plastic vials of 10- to 50-mL capacity.
2. Microscope, polarized light, with polarizer, analyzer, port for retardation plate, 360C graduated rotating stage, substage condenser with iris, lamp, lamp iris, and:
   a. Objective lenses: 10X, 20X, and 40X or near equivalent.
   b. Ocular lense: 10X minimum.
   c. Eyepiece reticle: crosshair.
   d. Dispersion staining objective lens or equivalent.
   e. Compensator plate: ca. 550 nm± 20 nm, retardation: "first order red" compensator.
3. Microscope slides: 75 mm x 25 mm.
4. Cover slips.
5. Ventilated hood or negative-pressure glove box.
6. Mortar and pestle: agate or porcelain.
7. Stereomicroscope, ca. 10 to 45X.
8. Light source: incandescent or fluorescent.
9. Tweezers, dissecting needles, spatulas, probes, and scalpels.
10. Glassine paper or clean glass plate.
11. Low-speed hand drill with coarse burr bit (optional).

SPECIAL PRECAUTIONS: Asbestos, a human carcinogen, should be handled only in an exhaust hood (equipped with a HEPA filter) [2]. Precautions should be taken when collecting unknown samples, which may be asbestos, to preclude exposure to the person collecting the sample and minimize the disruption to the parent material [3]. Disposal of asbestos-containing materials should follow EPA Guidelines [4].

SAMPLING:

1. Place 1 to 10 g of the material to be analyzed in a sample container.
   NOTE: For large samples (i.e., whole ceiling tiles) that are fairly homogenous, a representative small portion should be submitted for analysis. Sample size should be adjusted to ensure that it is representative of the parent material.
2. Make sure that sample containers are taped so they will not open in transit.
3. Ship the samples in a rigid container with sufficient packing material to prevent damage or sample loss.

SAMPLE PREPARATION:

4. Visually examine samples in the container and with a low-magnification stereomicroscope in a hood. (If necessary, a sample may be carefully removed from the container and placed on glassine transfer paper or clean glass plate for examination). Break off a portion of the sample and examine the edges for emergent fibers. Note the homogeneity of the sample. Some hard tiles can be broken, and the edges examined for emergent fibers. If fibers are found, make an estimate of the amount and type of fibers present, confirm fiber type (step 14) and quantify (step 15).
5. In a hood, open sample container and with tweezers remove small, representative portions of the sample.
   1. If there are obvious separable layers, sample and analyze each layer separately.

b. If the sample appears to be slightly inhomogeneous, mix it in the sample container with tweezers or a spatula before taking the portion of analysis. Alternatively, take small representative portions of each type of material and place on a glass slide.
c. On hard tiles that may have thin, inseparable layers, use a scalpel to cut through all the layers for a representative sample. Then cut it into smaller pieces after placing RI liquid on it before trying to reduce the thickness. Alternatively, use a low-speed hand drill equipped with a burr bit to remove material from hard tiles. Avoid excessive heating of the sample which may alter the optical properties of the material.
NOTE: This type of sample often requires ashing or other specialized preparation, and may require transmission electron microscopy for detection of the short asbestos fibers which are characteristic of floor tiles.
d. If the sample has large, hard particles, grind it in a mortar. Do not grind so fine that fiber characteristics are destroyed.
e. If necessary, treat a portion of the sample in a hood with an appropriate solvent to remove binders, tars, and other interfering materials which may be present in the sample. Make corrections for the non-asbestos material removed by this process.
NOTE: Other methods of sample preparation such as acid washing and sodium metaphosphate treatment and ashing may be necessary, especially to detect low concentrations of asbestos. If needed, use as described in Reference [1].

6. After placing a few drops of RI liquid on the slide, put a small portion of sample in the liquid. Tease apart with a needle or smash small clumps with the flat end of a spatula or probe, producing a uniform thickness or particles so that better estimates of projected area percentages can be made. Mix the fibers and particles on the slide so that they are as homogeneous as possible.
NOTE: An even dispersion of sample should cover the entire area under the cover slip. some practice will be necessary to judge the right amount of material to place on the slide. Too little sample may not give sufficient information and too much sample cannot be easily analyzed.

CALIBRATION AND QUALITY CONTROL:

7. Check for contamination each day of operation. Wipe microscope slides and cover slips with lens paper before using. Check refractive index liquids. Record results in a separate logbook.
8. Verify the refractive indices of the refractive index liquids used once per week of operation. Record these checks in a separate logbook.
9. Follow the manufacturer's instructions for illumination, condenser alignment and other microscope adjustments. Perform these adjustments prior to each sample set.
10. Determine percent of each identified asbestos species by comparison to standard projections (Figure 1) [1]. If no fibers are detected in a homogeneous sample, examine at least two additional preparations before concluding that no asbestos is present.
11. If it appears that the preparation technique might not be able to produce a homogeneous or representative sample on the slide, prepare a duplicate slide and average the results. Occasionally, when the duplicate results vary greatly, it will be necessary to prepare additional replicate slides and average all the replicate results. Prepare duplicate slides of at least 10% of the samples analyzed. Average the results for reporting.
12. Analyze about 5% blind samples of known asbestos content.
13. Laboratories performing this analytical method should participate in the National Voluntary Laboratory Accreditation Program [5] or a similar interlaboratory quality control program. Each analyst should have complete formal training in polarized light microscopy and its application to crystalline materials. In lieu of formal training, laboratory training in asbestos bulk analysis under the direction of a trained asbestos bulk analyst may be substituted. Owing to the subjective nature of the method, frequent practice is essential in order to remain proficient in estimating projected area percentages.

QUALITATIVE ASSESSMENT:

14. Scan the slide to identify any asbestos minerals using the optical properties of morphology,

refractive indices, color, pleochroism, birefringence, extinction characteristics, sign of elongation, and dispersion staining characteristics.

NOTE: Identification of asbestos using polarized light microscopy is unlike most other analytical methods. The quality of the results is dependent on the skill and judgment of the analyst. This method does not lend itself easily to a step-wise approach. Various procedures devised by different analysts may yield equivalent results. The following step-wise procedure repeatedly utilizes the sample preparation procedure previously outlined.

a. Prepare a slide using 1.550 HD RI liquid. Adjust the polarizing filter such that the polars are partially crossed, with ca. 15° offset. Scan the preparation, examining the morphology for the presence of fibers. If no fibers are found, scan the additional preparations. If no fibers are found in any of the preparations, report that the sample does not contain asbestos, and stop the analysis at this point.

b. If fibers are found, adjust the polarizing filter such that the polars are fully crossed. If all of the fibers are isotropic (disappear at all angles of rotation) then those fibers are not asbestos. Fibrous glass and mineral wool, which are common components of suspect samples, are isotropic. If only isotropic fibers are found in the additional preparations, report no asbestos fibers detected, and stop the analysis.

c. If anisotropic fibers are found, rotate the stage to determine the angle of extinction. Except for tremolite-actinolite asbestos which has oblique extinction at 10-20°, the other forms of asbestos exhibit parallel extinction (Table 1). Tremolite may show both parallel and oblique extinction.

d. Insert the first order red compensator plate in the microscope and determine the sign of elongation. All forms of asbestos have a positive sign of elongation except for crocidolite. If the sign of elongation observed is negative, go to step "g."

   NOTE: To determine the direction of the sign of elongation on a particular microscope configuration, examine a known chrysotile sample and note the direction (NE-SW or NW-SE) of the blue coloration. Chrysotile has a positive sign of elongation.

e. Remove the first-order red compensator and uncross the polarizer. Examine under plane polarized light for blue and gold-brown Becke colors at the fiber-oil interface (i.e., index of refraction match). Becke colors are not always evident. Examine fiber morphology for twisted, wavy bundles of fibers which are characteristic of chrysotile. Twisted, ribbon-like morphology with cellular internal features may indicate cellulose fibers. It may be necessary to cross the polars partially in order to see the fibers if the index of refraction is an exact match at 1.550. If the fibers appear to have higher index of refraction, go to step "h," otherwise continue.

f. Identification of chrysotile. Insert the dispersion staining objective. Observation of dispersion staining colors of blue and blue-magenta confirms chrysotile. Cellulose, which is a common interfering fiber at the 1.550 index of refraction, will not exhibit these dispersion staining colors. If chrysotile is found, go to step 15 for quantitative estimation.

g. Identification of crocidolite. Prepare a slide in 1.700 RI liquid. Examine under plane-polarized light (uncrossed polars); check for morphology of crocidolite. Fibers will be straight, with rigid appearance, and may appear blue or purple-blue. Crocidolite is pleochroic, i.e., it will appear to change its color (blue or gray) as it is rotated through plane polarized light. Insert the dispersion staining objective. The central stop dispersion staining color are red magenta and blue magenta, however, these colors are sometimes difficult to impossible to see because of the opacity of the dark blue fibers. If observations above indicate crocidolite, go to step 15 for quantitative estimation.

h. Identification of amosite. Prepare a slide in 1.680 RI liquid. Observed the fiber morphology for amosite characteristics: straight fibers and fiber bundles with broom-like or splayed ends. If the morphology matches amosite, examine the fibers using the dispersion staining objective. Blue and pale blue colors indicate the cummingtonite form of amosite, and gold and blue colors indicate the grunerite form of amosite. If amosite is confirmed by this test, go to step 15 for quantitative estimation, otherwise continue.

i. Identification of anthophyllite-tremolite-actinolite. Prepare a slide in 1.605 HD RI liquid. Examine morphology for comparison to anthophyllite-tremolite-actinolite asbestos. The refractive indices for these forms of asbestos vary naturally within the species. Anthophyllite can be distinguished from actinolite and tremolite by its nearly parallel extinction. Actinolite has a light to dark green color under plane-polarized light and exhibits some pleochroism. For all three, fibers will be straight, single fibers possibly with some larger composite fibers. Cleavage fragments may also be present. Examine using the central stop dispersion staining objective. Anthophyllite will exhibit central stop colors of blue and gold/gold-magenta; tremolite will exhibit pale blue and yellow; and actinolite will exhibit magenta and golden-yellow colors.

NOTE: In this refractive index range, wollastonite is a common interfering mineral with similar morphology including the presence of cleavage fragments. It has both positive and negative sign of elongation, parallel extinction, and central stop dispersion staining colors of pale yellow and pale yellow to magenta. If further confirmation of wollastonite versus anthophyllite is needed, go to step "j". If any of the above forms of asbestos were confirmed above, go to step 15 for quantitative estimation. If none of the tests above confirmed asbestos fibers, examine the additional preparations and if the same result occurs, report the absence of asbestos in this sample.

j. Wash a small portion of the sample in a drop of concentrated hydrochloric acid on a slide. Place the slide, with cover slip in place, on a warm hot plate until dry. By capillary action, place 1.620 RI liquid under the cover clip and examine the slide. Wollastonite fibers will have a "cross-hatched" appearance across the length of the fibers and will not show central stop dispersion colors. Anthophyllite and tremolite will still show their original dispersion colors.

NOTE: There are alternative analysis procedures to the step-wise approach outlined above which will yield equivalent results. Some of these alternatives are:

i. Perform the initial scan for the presence of asbestos using crossed polars as well as the first-order red compensator. This allows for simultaneous viewing of birefringent and amorphous materials as well as determine their sign of elongation. Some fibers which are covered with mortar may best be observed using this configuration.

ii. Some analysts prefer to mount their first preparation in a RI liquid different than any asbestos materials and conduct their initial examination under plane-polarized light.

iii. If alternative RI liquids are used from those specified, dispersion staining colors observed will also change. Refer to an appropriate reference for the specific colors associated with asbestos in the RI liquids actually used.

QUANTITATIVE ASSESSMENT:

15. Estimate the content of the asbestos type present in the sample using the 1.550 RI preparation. Express the estimate as an area percent of all material present, taking into account the loading and distribution of all sample material on the slide. Use Figure 1 as an aid in arriving at your estimate. If additional unidentified fibers are present in the sample, continue with the qualitative measurement (step 14).

    NOTE: Point-counting techniques to determine percentages of the asbestos minerals are not generally recommended. The point-counting method only produces accurate quantitative data when the material on the slide is homogeneous and has a uniform thickness, which is difficult to obtain [6]. The point-counting technique is, recommended by the EPA to determine the amount of asbestos in bulk [1]; however, in the more recent Asbestos Hazard Emergency Response Act (AHERA) regulations, asbestos quantification may be performed by a point-counting or equivalent estimation method [7].

16. Make a quantitative estimate of the asbestos content of the sample from the appropriate combination of the estimates from both the gross and microscopic examinations. If asbestos fibers are identified, report the material as "asbestos-containing". Asbestos content should be reported as a range of percent content. The range reported should be indicative of the analyst's precision in estimating asbestos content. For greater quantities use Figure 1 in arriving at your estimate.

EVALUATION OF METHOD:

The method is compiled from standard techniques used in mineralogy [8-13], and from standard laboratory procedures for bulk asbestos analysis which have been utilized for several years. These techniques have been successfully applied to the analysis of EPA Bulk Sample Analysis Quality Assurance Program samples since 1982 [1,5]. However, no formal evaluation of this method, as written, has been performed.

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METHOD WRITTEN BY:

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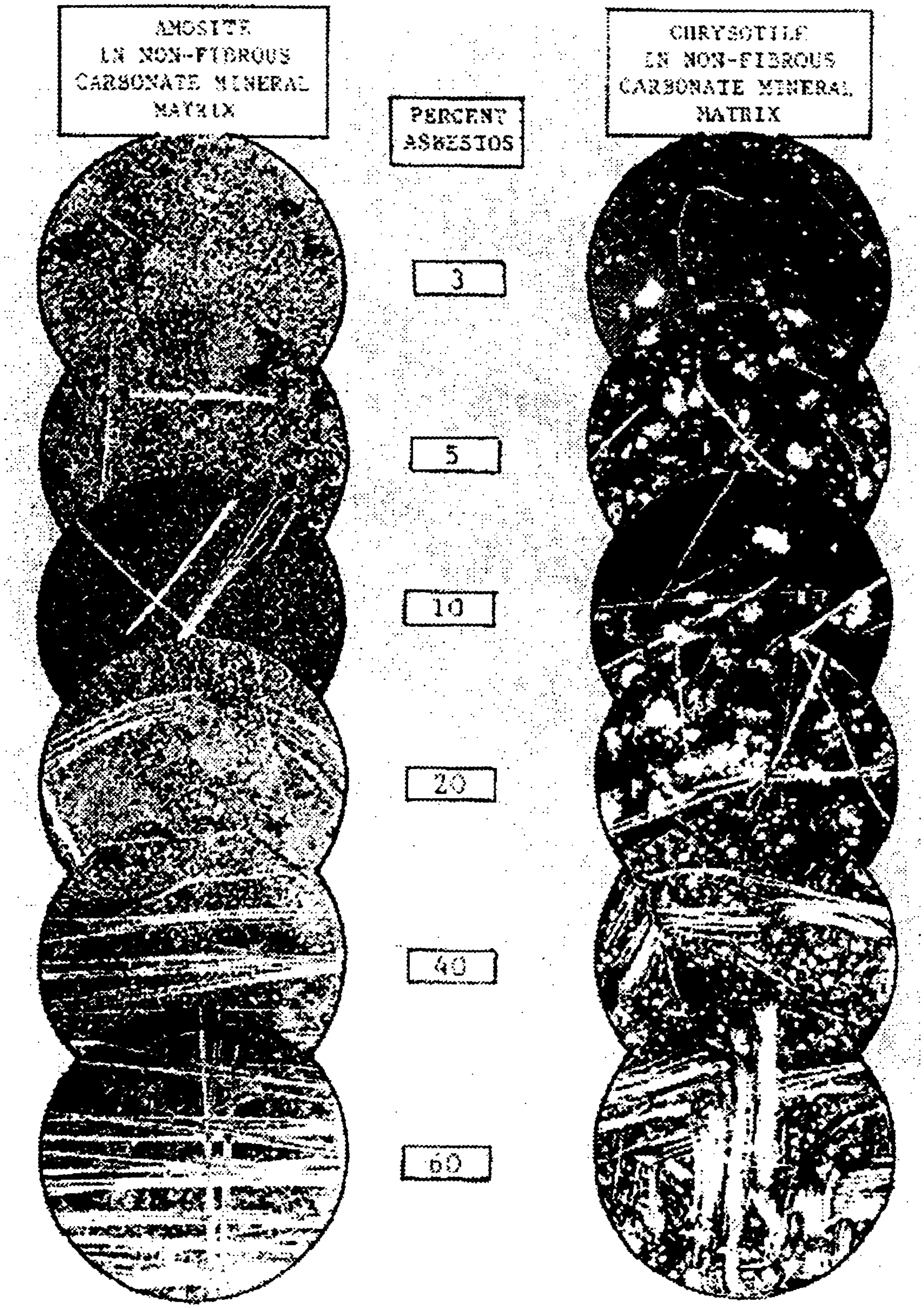

Figure 1. Percent estimate comparator

Table 1. Optical Properties of Asbestos Fibers

		Refractive Index (Approximate Values)		
Mineral	Morphology and Color	⊥ to Elongation	‖ to Elongation	Birefringence
Chrysotile	Wavy fibers with kinks Splayed ends on larger bundles. Colorless to light brown upon being heated. Nonpleochroic. Aspect ratio typically >10:1.	1.54	1.55	0.002 - 0.014
Cummingtonite-Grunerite (Amosite)	Straight fibers and fiber bundles. Bundle ends appear broom-like or splayed. Colorless to brown upon heating. May be weakly pleochroic. Aspect ratio typically >10:1.	1.67	1.70	0.02 - 0.03
Crocidolite (Riebeckite)	Straight fibers and fiber bundles. Longer fibers show curvature. Splayed ends on bundles. Characteristic blue color. Pleochroic. Aspect ratio typically >10:1.	1.71	1.70	0.014 - 0.016 Interference colors may be masked by blue color.
Anthophyllite	Straight fibers and fiber bundles. Cleavage fragments may be present. Colorless to light brown. Nonpleochroic to weakly pleochroic. Aspect ratio generally <10:1.	1.61	1.63	0.019 - 0.024
Tremolite-Actinolite	Straight and curved fibers. Cleavage fragments common. Large fiber bundles show splayed ends. Tremolite is colorless. Actinolite is green and weakly to moderately pleochroic. Aspect ratio generally <10:1.	1.60 - 1.62 (tremolite) 1.62 - 1.67 (actinolite)	1.62 - 1.64 (tremolite) 1.64 - 1.68 (actinolite)	0.02 - 0.03

Table 1. Optical Properties of Asbestos Fibers (Continued)

			Central Stop Dispersion Staining Colors		
Mineral	Extinction	Sign of Elongation	RI Liquid	⊥ to Vibration	∥ to Vibration
Chrysotile	Parallel to fiber length	+ (length slow)	1.550 HD	Blue	Blue-magenta
Cummingtonite-Grunerite (Amosite)	Parallel to fiber length	+ (length slow)	1.670 Fibers subjected to high temperatures will not dispersion-stain.	Red magenta to blue	Yellow
Cummingtonite Grunerite			1.680 1.680	pale blue blue	blue gold
Crocidolite (Riebeckite)	Parallel to fiber length	- (length fast)	1.700 1.680	Red magenta yellow	Blue-magenta pale yellow
Anthophyllite	Parallel to fiber length	+ (length slow)	1.605 HD 1.620 HD	Blue Blue-green	Gold to gold-magenta Golden-yellow
Tremolite-Actinolite	Oblique - 10 to 20° for fragments. Some composite fibers show ∥ extinction.	+ (length slow)	1.605 HD	Pale blue (tremolite) Yellow (actinolite)	Yellow (tremolite) Pale yellow (actinolite)

HD = high-dispersion RI liquid series.

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Appendix A to Subpart E of Part 763 -- Interim Transmission Electron Microscopy Analytical Methods -- Mandatory and Nonmandatory -- and Mandatory Section to Determine Completion of Response Actions

I. Introduction

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm 3.

2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by

this method is equal to or greater than 5:1.

4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm 2 in an area of 0.057 mm 2 (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm 2 for any single preparation for that same area.

6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.

9. *Fiber* -- A structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm 2.

14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD* -- No structure detected.

16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.

17. *PCM* -- Phase contrast microscopy.

18. *SAED* -- Selected area electron diffraction.

19. *SEM* -- Scanning electron microscope.

20. *STEM* -- Scanning transmission electron microscope.

21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm 3* -- Structures per cubic centimeter.

23. *S/mm 2* -- Structures per square millimeter.

24. *TEM* -- Transmission electron microscope. B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.

2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).

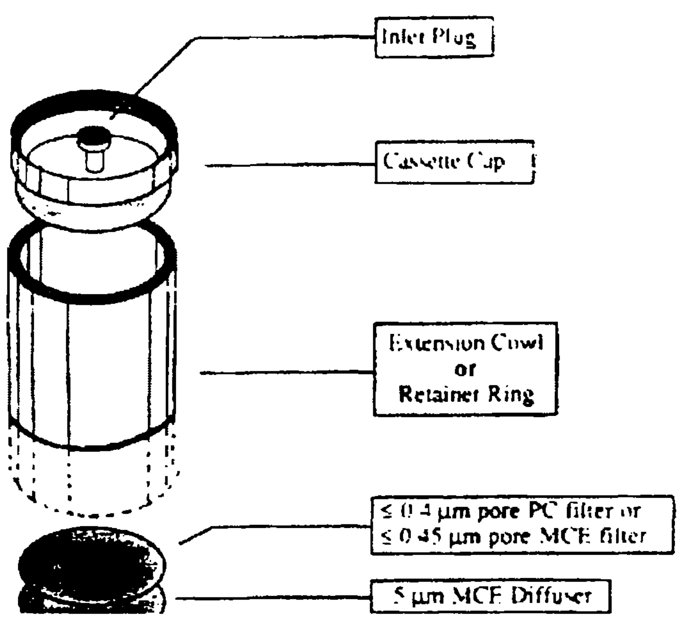
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.

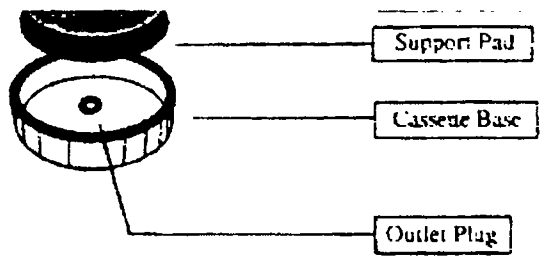
4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm 2 in an area of 0.057 mm 2 (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm 2 for that same area is acceptable for this method.

5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.

6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





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7. Reloading of used cassettes is not permitted.

8. Orient the cassette downward at approximately 45 degrees from the horizontal.

9. Maintain a log of all pertinent sampling information.

10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.

11. Record all calibration information.

12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.

14. The final plastic barrier around the abatement area remains in place for the sampling period.

15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)

16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

17. A minimum of 13 samples are to be collected for each testing site consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each abatement area.

ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE I--NUMBER OF 200 MESH EM GRID OPENINGS (0.0057 mm^2) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

	Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm		
	Volume (liters)	# of grid openings	Volume (liters)	# of grid openings	
	560	24	1,250	24	
	600	23	1,300	23	
	700	19	1,400	21	
	800	17	1,600	19	
	900	15	1,800	17	
	1,000	14	2,000	15	
	1,100	12	2,200	14	
Recommended Volume Range	1,200	11	2,400	13	
Recommended Volume Range	1,300	10	2,600	12	
Recommended Volume Range	1,400	10	2,800	11	Recommended Volume Range
Recommended Volume Range	1,500	9	3,000	10	Recommended Volume Range
Recommended Volume Range	1,600	8	3,200	9	Recommended Volume Range
Recommended Volume Range	1,700	8	3,400	9	Recommended Volume Range
Recommended Volume Range	1,800	8	3,600	8	Recommended Volume Range
	1,900	7	3,800	8	Recommended Volume Range
	2,000	7	4,000	8	Recommended Volume Range
	2,100	6	4,200	7	
	2,200	6	4,400	7	
	2,300	6	4,600	7	
	2,400	6	4,800	6	
	2,500	5	5,000	6	
	2,600	5	5,200	6	
	2,700	5	5,400	6	
	2,800	5	5,600	5	
	2,900	5	5,800	5	
	3,000	5	6,000	5	
	3,100	4	6,200	5	
	3,200	4	6,400	5	
	3,300	4	6,600	5	
	3,400	4	6,800	4	
	3,500	4	7,000	4	
	3,600	4	7,200	4	
	3,700	4	7,400	4	
	3,800	4	7,500	4	

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

20. Ensure that the sampler is turned upright before interrupting the pump flow.

21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.

22. Ensure that the samples are stored in a secure and representative location.

23. Do not change containers if portions of these filters are taken for other purposes.

24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE II--SUMMARY OF SAMPLING AGENCY DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, completeness, representativeness, and comparability. These objectives are assured by the periodic control checks and reference checks listed here and described in the text of the method.

Unit Operation	QC Check	Frequency	Conformance Expectation
Sampling materials	Sealed blank	1 per I/O site	95%
Sample procedures	Field blanks	2 per I/O site	95%
	Pump calibration	Before and after each field series	90%
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample shipment	Review of sending report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples. D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected. E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

>**Note:** The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm 2 in an area of 0.057 mm 2 (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm 2 for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1-2 µm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.
F. TEM Method

1. An 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160

lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80-120 kV, grid assessment 250-1,000X, then 15,000-20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

a. Less than 50 percent of the grid openings covered by the replica are intact.

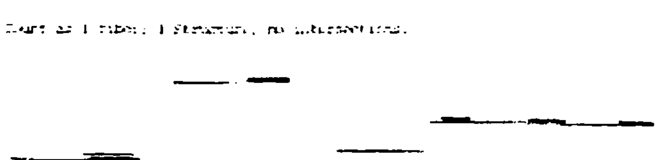
b. The replica is doubled or folded.

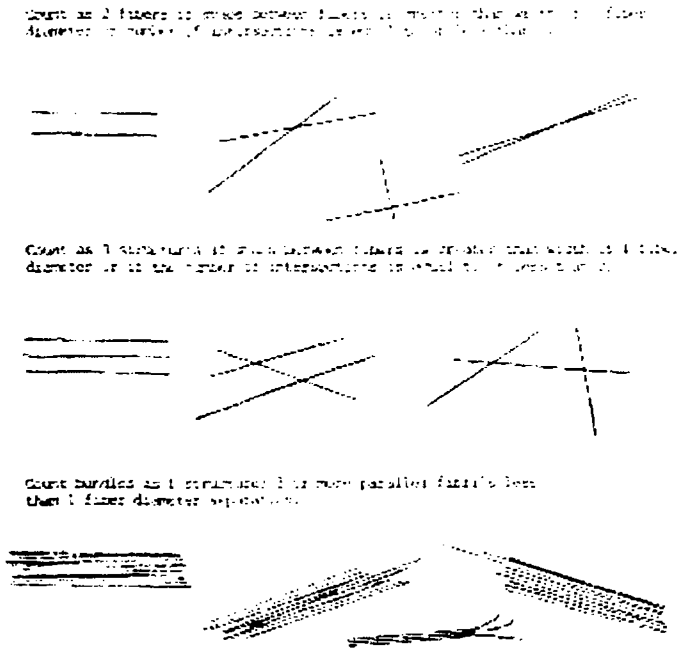
c. The replica is too dark because of incomplete dissolution of the filter.

9. *Recording Rules.*

a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 µm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES





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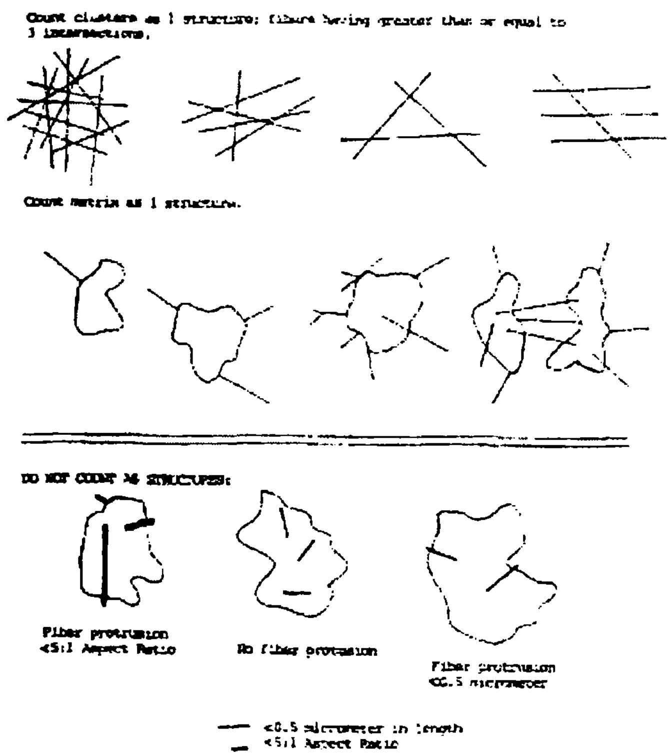

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i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

b. Separate categories will be maintained for fibers less than 5 µm and for fibers equal to or greater than 5 µm in length.

c. Record NSD when no structures are detected in the field.

d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm 2 concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.

f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the 70 s/mm 2 concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm 2 concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.

h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after 70 s/mm 2 have been exceeded for a particular sample.

i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after 70 s/mm 2 have been exceeded for a particular sample.)

j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.

k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.

m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

a. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

b. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

c. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

d. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.

2. Carry out visual inspection of work site prior to air monitoring.

3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix. H. Reporting

1. The following information must be reported to the client for each sample analyzed:

a. Concentration in structures per square millimeter and structures per cubic centimeter.

b. Analytical sensitivity used for the analysis.

c. Number of asbestos structures.

d. Area analyzed.

e. Volume of air sampled (which must be initially supplied to lab by client).

f. Copy of the count sheet must be included with the report.

g. Signature of laboratory official to indicate that the laboratory met specifications of the method.

h. Report form must contain official laboratory identification (e.g., letterhead).

i. Type of asbestos. I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	80% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm 2 per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.

6. Perform a system check on the transmission electron microscope daily.

7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.

8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.

9. Validate all data entries.

10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.

11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.

12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures. J. References

For additional background information on this method, the following references should be consulted.

1. "Guidance for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.

2. "Measuring Airborne Asbestos Following an Abatement Action," USEPA, Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.

3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619, 1982.

4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.

5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Burdette, G.J., Health & Safety Exec. Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc., "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters," WERL SOP 87-1. March 5, 1987.

9. NIOSH Method 7402 for Asbestos Fibers, 12-11-86 Draft.

10. Yamate, G., Agarwall, S.C., Gibbons, R.D., IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy," Draft report, USEPA Contract 68-02-3266, July 1984.

11. "Guidance to the Preparation of Quality Assurance Project Plans," USEPA, Office of Pollution Prevention and Toxics, 1984.

III. Nonmandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 s/cm 3.

2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm 2 in an area of 0.057 mm 2 (nominally 10 200 mesh grid openings) and a maximum of 53 structures/mm 2 for no more than one single preparation for that same area.

6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.

9. *Fiber* -- A structure greater than or equal to 0.5 μm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on blanks (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm 2.

14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD* -- No structure detected.

16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.

17. *PCM* -- Phase contrast microscopy.

18. *SAED* -- Selected area electron diffraction.

19. *SEM* -- Scanning electron microscope.

20. *STEM* -- Scanning transmission electron microscope.

21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm 3* -- Structures per cubic centimeter.

23. *S/mm 2* -- Structures per square millimeter.

24. *TEM* -- Transmission electron microscope. B. Sampling

1. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (See References 1, 2, and 5 of Unit III.L.) Special precautions should be taken to avoid contamination of the sample. For example, materials that have not been prescreened for their asbestos background content should not be used; also, sample handling procedures which do not take cross contamination possibilities into account should not be used.

2. Material and supply checks for asbestos contamination should be made on all critical supplies, reagents, and procedures before their use in a monitoring study.

3. Quality control and quality assurance steps are needed to identify problem areas and isolate the cause of the contamination (see Reference 5 of Unit III.L.). Control checks shall be permanently recorded to document the quality of the information produced. The sampling firm must have written quality control procedures and documents which verify compliance. Independent audits by a qualified consultant or firm should be performed once a year. All documentation of compliance should be retained indefinitely to provide a guarantee of quality. A summary of Sample Data Quality Objectives is shown in Table II of Unit II.B.

4. Sampling materials.

a. Sample for airborne asbestos following an abatement action using commercially available cassettes.

b. Use either a cowling or a filter-retaining middle piece. Conductive material may reduce the potential for particulates to adhere to the walls of the cowl.

c. Cassettes must be verified as "clean" prior to use in the field. If packaged filters are used for loading or preloaded cassettes are purchased from the manufacturer or a distributor, the manufacturer's name and lot number should be entered on all field data sheets provided to the laboratory, and are required to be listed on all reports from the laboratory.

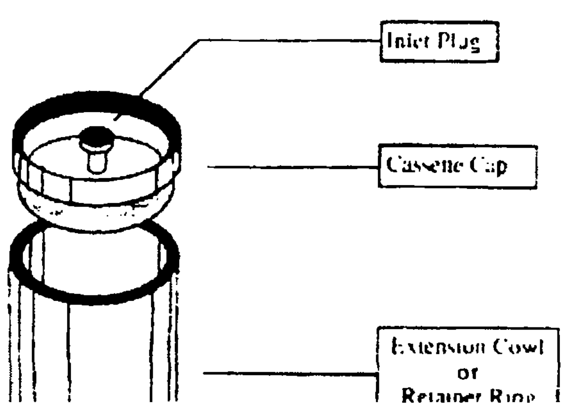
d. Assemble the cassettes in a clean facility (See definition of clean area under Unit III.A.).

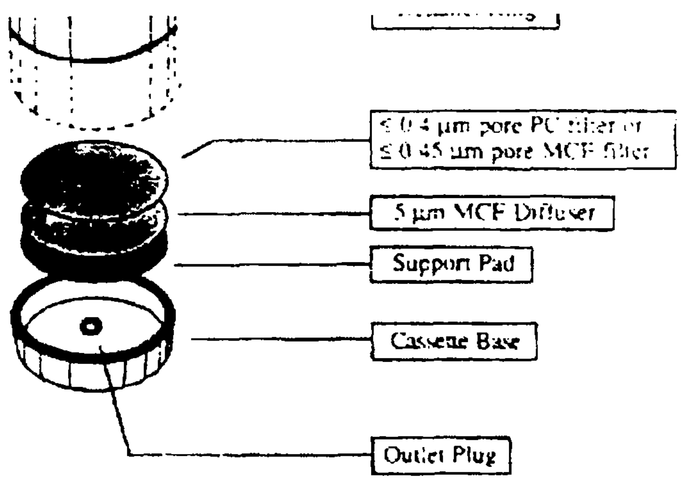
e. Reloading of used cassettes is not permitted.

f. Use sample collection filters which are either polycarbonate having a pore size of less than or equal to 0.4 μm or mixed cellulose ester having a pore size of less than or equal to 0.45 μm.

g. Place these filters in series with a backup filter with a pore size of 5.0 μm (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





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h. When polycarbonate filters are used, position the highly reflective face such that the incoming particulate is received on this surface.

i. Seal the cassettes to prevent leakage around the filter edges or between cassette part joints. A mechanical press may be useful to achieve a reproducible leak-free seal. Shrink fit gel-bands may be used for this purpose and are available from filter manufacturers and their authorized distributors.

j. Use wrinkle-free loaded cassettes in the sampling operation.

5. Pump setup.

a. Calibrate the sampling pump over the range of flow rates and loads anticipated for the monitoring period with this flow measuring device in series. Perform this calibration using guidance from EPA Method 2A each time the unit is sent to the field (See Reference 6 of Unit III.L.).

b. Configure the sampling system to preclude pump vibrations from being transmitted to the cassette by using a sampling stand separate from the pump station and making connections with flexible tubing.

c. Maintain continuous smooth flow conditions by damping out any pump action fluctuations if necessary.

d. Check the sampling system for leaks with the end cap still in place and the pump operating before initiating sample collection. Trace and stop the source of any flow indicated by the flowmeter under these conditions.

e. Select an appropriate flow rate equal to or greater than 1 L/min or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

f. Orient the cassette downward at approximately 45 degrees from the horizontal.

g. Maintain a log of all pertinent sampling information, such as pump identification number, calibration data, sample location, date, sample identification number, flow rates at the beginning, middle, and end, start and stop times, and other useful information or comments. Use of a sampling log form is recommended. See the following Figure 2:

FIGURE 2--SAMPLING LOG FORM

Sample Number	Location of Sample	Pump I.D.	Start Time	Middle Time	End Time	Flow Rate

Inspector: ____________________ Date: ____________

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h. Initiate a chain of custody procedure at the start of each sampling, if this is requested by the client.

i. Maintain a close check of all aspects of the sampling operation on a regular basis.

j. Continue sampling until at least the minimum volume is collected, as specified in the following Table I:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS (0.0057 MM²) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm

Volume (liters)	# of grid openings	
560	24	
600	23	
700	19	
800	17	
900	15	
1,000	14	
1,100	12	
1,200	11	Recommended Volume Range
1,300	10	Recommended Volume Range
1,400	10	Recommended Volume Range
1,500	9	Recommended Volume Range
1,600	8	Recommended Volume Range
1,700	8	Recommended Volume Range
1,800	8	Recommended Volume Range
1,900	7	
2,000	7	
2,100	6	
2,200	6	
2,300	6	
2,400	6	
2,500	5	
2,600	5	
2,700	5	
2,800	5	
2,900	5	
3,000	5	
3,100	4	
3,200	4	
3,300	4	
3,400	4	
3,500	4	
3,600	4	
3,700	4	
3,800	4	

Effective Filter Area 855 sq mm

Volume (liters)	# of grid openings	
1,250	24	
1,300	23	
1,400	21	
1,600	19	
1,800	17	
2,000	15	
2,200	14	
2,400	13	
2,600	12	
2,800	11	Recommended Volume Range
3,000	10	Recommended Volume Range
3,200	9	Recommended Volume Range
3,400	9	Recommended Volume Range
3,600	8	Recommended Volume Range
3,800	8	Recommended Volume Range
4,000	8	Recommended Volume Range
4,200	7	
4,400	7	
4,600	7	
4,800	6	
5,000	6	
5,200	6	
5,400	6	
5,600	5	
5,800	5	
6,000	5	
6,200	5	
6,400	5	
6,600	5	
6,800	4	
7,000	4	
7,200	4	
7,400	4	
7,600	4	

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

k. At the conclusion of sampling, turn the cassette upward before stopping the flow to minimize possible particle loss. If the sampling is resumed, restart the flow before reorienting the cassette downward. Note the condition of the filter at the conclusion of sampling.

l. Double check to see that all information has been recorded on the data collection forms and that the cassette is securely closed and appropriately identified using a waterproof label. Protect cassettes in individual clean resealed polyethylene bags. Bags are to be used for storing cassette caps when they are removed for sampling purposes. Caps and plugs should only be removed or replaced using clean hands or clean disposable plastic gloves.

m. Do not change containers if portions of these filters are taken for other purposes.

6. Minimum sample number per site. A minimum of 13 samples are to be collected for each testing consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 sec and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each ambient area.

ii. At one of the ambient sites.

(**Note:** Do not leave the blank open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

7. Abatement area sampling.

a. Conduct final clearance sampling only after the primary containment barriers have been removed; the abatement area has been thoroughly dried; and, it has passed visual inspection tests by qualified personnel. (See Reference 1 of Unit III.L.)

b. Containment barriers over windows, doors, and air passageways must remain in place until the TEM clearance sampling and analysis is completed and results meet clearance test criteria. The final plastic barrier remains in place for the sampling period.

c. Select sampling sites in the abatement area on a random basis to provide unbiased and representative samples.

d. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust.

i. Equipment used in aggressive sampling such as a leaf blower and/or fan should be properly cleaned and decontaminated before use.

ii. Air filtration units shall remain on during the air monitoring period.

iii. Prior to air monitoring, floors, ceiling and walls shall be swept with the exhaust of a minimum one (1) horsepower leaf blower.

iv. Stationary fans are placed in locations which will not interfere with air monitoring equipment. Fan air is directed toward the ceiling. One fan shall be used for each 10,000 ft 3 of worksite.

v. Monitoring of an abatement work area with high-volume pumps and the use of circulating fans will require electrical power. Electrical outlets in the abatement area may be used if available. If no such outlets are available, the equipment must be supplied with electricity by the use of extension cords and strip plug units. All electrical power supply equipment of this type must be approved Underwriter Laboratory equipment that has not been modified. All wiring must be grounded. Ground fault interrupters should be used. Extreme care must be taken to clean up any residual water and ensure that electrical equipment does not become wet while operational.

vi. Low volume pumps may be carefully wrapped in 6-mil polyethylene to insulate the pump from the air. High volume pumps cannot be sealed in this manner since the heat of the motor may melt the plastic. The pump exhausts should be kept free.

vii. If recleaning is necessary. removal of this equipment from the work area must be handled with care. It is not possible to completely decontaminate the pump motor and parts since these areas cannot be wetted. To minimize any problems in this area, all equipment such as fans and pumps should be carefully wet wiped prior to removal from the abatement area. Wrapping and sealing low volume pumps in 6-mil polyethylene will provide easier decontamination of this equipment. Use of clean water and disposable wipes should be available for this purpose.

e. Pump flow rate equal to or greater than 1 L/min or less than 10 L/min may be used for 25 mm cassettes. The larger cassette diameters may have comparably increased flow.

f. Sample a volume of air sufficient to ensure the minimum quantitation limits. (See Table I of Unit III.B.5.j.)

8. Ambient sampling.

a. Position ambient samplers at locations representative of the air entering the abatement site. If makeup air entering the abatement site is drawn from another area of the building which is outside of the abatement area, place the pumps in the building, pumps should be placed out of doors located near the building and away from any obstructions that may influence wind patterns. If construction is in progress immediately outside the enclosure, it may be necessary to select another ambient site. Samples should be representative of any air entering the work site.

b. Locate the ambient samplers at least 3 ft apart and protect them from adverse weather conditions.

c. Sample same volume of air as samples taken inside the abatement site. C. Sample Shipment

1. Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

2. Select a rigid shipping container and pack the cassettes upright in a noncontaminating nonfibrous medium such as a bubble pack. The use of resealable polyethylene bags may help to prevent jostling of individual cassettes.

3. Avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials because of possible contamination.

4. Include a shipping bill and a detailed listing of samples shipped, their descriptions and all identifying numbers or marks, sampling data, shipper's name, and contact information. For each sample set, designate which are the ambient samples, which are the abatement area samples, which are the field blanks, and which is the sealed blank if sequential analysis is to be performed.

5. Hand-carry samples to the laboratory in an upright position if possible; otherwise choose that mode of transportation least likely to jar the samples in transit.

6. Address the package to the laboratory sample coordinator by name when known and alert him or her of the package description, shipment mode, and anticipated arrival as part of the chain of custody and sample tracking procedures. This will also help the laboratory schedule timely analysis for the samples when they are received. D. Quality Control/Quality Assurance Procedures (Data Quality

Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined, and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the text below.

1. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm 2 in an area of 0.057 mm 2 (nominally 10 200-mesh grid openings) and a maximum of 53 s/mm 2 for that same area for any single preparation is acceptable for this method.

2. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter -- not the filter which will be used in sampling -- before and after the sampling operation.

3. Record all calibration information with the data to be used on a standard sampling form.

4. Ensure that the samples are stored in a secure and representative location.

5. Ensure that mechanical calibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

6. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by installing a damping chamber if necessary.

7. Open a loaded cassette momentarily at one of the indoor sampling sites when sampling is initiated. This sample will serve as an indoor field blank.

8. Open a loaded cassette momentarily at one of the outdoor sampling sites when sampling is initiated. This sample will serve as an outdoor field blank.

9. Carry a sealed blank into the field with each sample series. Do not open this cassette in the field.

10. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

11. Ensure that the sampler is turned upright before interrupting the pump flow.

12. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory. E. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Adhere to the following procedures to ensure both the continued chain-of-custody and the accountability of all samples passing through the laboratory:

a. Note the condition of the shipping package and data written on it upon receipt.

b. Retain all bills of lading or shipping slips to document the shipper and delivery time.

c. Examine the chain-of-custody seal, if any, and the package for its integrity.

d. If there has been a break in the seal or substantive damage to the package, the sample coordinator shall immediately notify the shipper and a responsible laboratory manager before any action is taken to unpack the shipment.

e. Packages with significant damage shall be accepted only by the responsible laboratory manager after discussions with the client.

3. Unwrap the shipment in a clean, uncluttered facility. The sample coordinator or his or her designee will record the contents, including a description of each item and all identifying numbers or marks. A Sample Receiving Form to document this information is attached for use when necessary. (See the following Figure 3.)

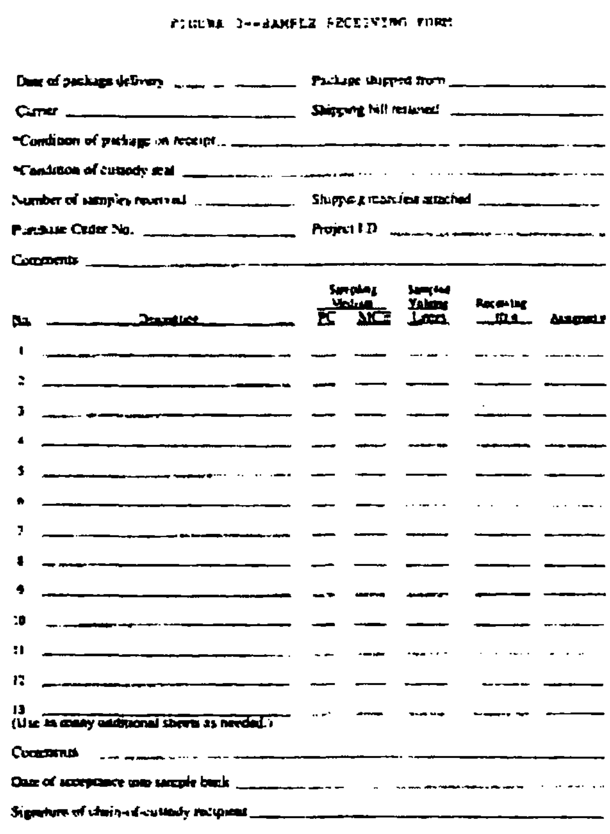


FIGURE 3--SAMPLE RECEIVING FORM

Date of package delivery ______ Package shipped from ______

Carrier ______ Shipping bill retained? ______

*Condition of package on receipt ______

*Condition of custody seal ______

Number of samples received ______ Shipping manifest attached ______

Purchase Order No. ______ Project I.D. ______

Comments ______

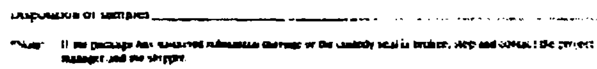
No.	Description	Sampling Medium PC	Sampling Medium MCE	Sampled Volume Liters	Receiving ID's	Assigned
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

(Use as many additional sheets as needed.)

Comments ______

Date of acceptance into sample bank ______

Signature of chain-of-custody recipient ______



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Note: The person breaking the chain-of-custody seal and itemizing the contents assumes responsibility for the shipment and signs documents accordingly.

4. Assign a laboratory number and schedule an analysis sequence.

5. Manage all chain-of-custody samples within the laboratory such that their integrity can be ensured and documented. F. Sample Preparation

1. Personnel not affiliated with the Abatement Contractor shall be used to prepare samples and conduct TEM analysis. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them to the clean sample preparation facility.

2. Perform sample preparation in a well-equipped clean facility.

Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA filtered. The cumulative analytical blank concentration must average less than 18 s/mm 2 in an area of 0.057 s/mm 2 (nominally 10 200-mesh grid openings) with no more than one single preparation to exceed 53 s/mm 2 for that same area.

3. Preparation areas for air samples must be separated from preparation areas for bulk samples. Personnel must not prepare air samples if they have previously been preparing bulk samples without performing appropriate personal hygiene procedures, i.e., clothing change, showering, etc.

4. *Preparation.* Direct preparation techniques are required. The objective is to produce an intact carbon film containing the particulates from the filter surface which is sufficiently clear for TEM analysis. Currently recommended direct preparation procedures for polycarbonate (PC) and mixed cellulose ester (MCE) filters are described in Unit III.F.7. and 8. Sample preparation is a subject requiring additional research. Variation on those steps which do not substantively change the procedure, which improve filter clearing or which reduce contamination problems in a laboratory are permitted.

a. Use only TEM grids that have had grid opening areas measured according to directions in Unit III.J.

b. Remove the inlet and outlet plugs prior to opening the cassette to minimize any pressure differential that may be present.

c. Examples of techniques used to prepare polycarbonate filters are described in Unit III.F.7.

d. Examples of techniques used to prepare mixed cellulose ester filters are described in Unit III.F.8.

e. Prepare multiple grids for each sample.

f. Store the three grids to be measured in appropriately labeled grid holders or polyethylene capsules.

5. Equipment.

a. Clean area.

b. Tweezers. Fine-point tweezers for handling of filters and TEM grids.

c. Scalpel Holder and Curved No. 10 Surgical Blades.

d. Microscope slides.

e. Double-coated adhesive tape.

f. Gummed page reinforcements.

g. Micro-pipet with disposal tips 10 to 100 μL variable volume.

h. Vacuum coating unit with facilities for evaporation of carbon. Use of a liquid nitrogen cold trap above the diffusion pump will minimize the possibility of contamination of the filter surface by oil from the pumping system. The vacuum-coating unit can also be used for deposition of a thin film of gold.

i. *Carbon rod electrodes.* Spectrochemically pure carbon rods are required for use in the vacuum evaporator for carbon coating of filters.

j. *Carbon rod sharpener.* This is used to sharpen carbon rods to a neck. The use of necked carbon rods (or equivalent) allows the carbon to be applied to the filters with a minimum of heating.

k. *Low-temperature plasma asher.* This is used to etch the surface of collapsed mixed cellulose ester (MCE) filters. The asher should be supplied with oxygen, and should be modified as necessary to provide a throttle or bleed valve to control the speed of the vacuum to minimize disturbance of the filter. Some early models of ashers admit air too rapidly, which may disturb particulates on the surface of the filter during the etching step.

l. *Glass petri dishes, 10 cm in diameter, 1 cm high.* For prevention of excessive evaporation of solvent when these are in use, a good seal must be provided between the base and the lid. The seal can be improved by grinding the base and lid together with an abrasive grinding material.

m. Stainless steel mesh.

n. Lens tissue.

o. Copper 200-mesh TEM grids, 3 mm in diameter, or equivalent.

p. Gold 200-mesh TEM grids, 3 mm in diameter, or equivalent.

q. Condensation washer.

r. Carbon-coated, 200-mesh TEM grids, or equivalent.

s. Analytical balance, 0.1 mg sensitivity.

t. Filter paper, 9 cm in diameter.

u. Oven or slide warmer. Must be capable of maintaining a temperature of 65-70 °C.

v. Polyurethane foam, 6 mm thickness.

w. Gold wire for evaporation.

6. Reagents.

a. *General.* A supply of ultra-clean, fiber-free water must be available for washing of all components used in the analysis. Water that has been distilled in glass or filtered or deionized water is satisfactory for this purpose. Reagents must be fiber-free.

b. Polycarbonate preparation method -- chloroform.

c. Mixed Cellulose Ester (MCE) preparation method -- acetone or the Burdette procedure (Ref. 7 of Unit III.L.).

7. TEM specimen preparation from polycarbonate filters.

a. *Specimen preparation laboratory.* It is most important to ensure that contamination of TEM specimens by extraneous asbestos fibers is minimized during preparation.

b. Cleaning of sample cassettes. Upon receipt at the analytical laboratory and before they are taken into the clean facility or laminar flow hood, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces.

c. Preparation of the carbon evaporator. If the polycarbonate filter has already been carbon-coated prior to receipt, the carbon coating step will be omitted, unless the analyst believes the carbon film is too thin. If there is a need to apply more carbon, the filter will be treated in the same way as an uncoated filter. Carbon coating must be performed with a high-vacuum coating unit. Units that are based on evaporation of carbon filaments in a vacuum generated only by an oil rotary pump have not been evaluated for this application, and must not be used. The carbon rods should be sharpened by a carbon rod sharpener to necks of about 4 mm long and 1 mm in diameter. The rods are installed in the evaporator in such a manner that the points are approximately 10 to 12 cm from the surface of a microscope slide held in the rotating and tilting device.

d. Selection of filter area for carbon coating. Before preparation of the filters, a 75 mm x 50 mm microscope slide is washed and dried. This slide is used to support strips of filter during the carbon evaporation. Two parallel strips of double-sided adhesive tape are applied along the length of the slide. Polycarbonate filters are easily stretched during handling, and cutting of areas for further preparation must be performed with great care. The filter and the MCE backing filter are removed together from the cassette and placed on a cleaned glass microscope slide. The filter can be cut with a curved scalpel blade by rocking the blade from the point placed in contact with the filter. The process can be repeated to cut a strip approximately 3 mm wide across the diameter of the filter. The strip of polycarbonate filter is separated from the corresponding strip of backing filter and carefully placed so that it bridges the gap between the adhesive tape strips on the microscope slide. The filter strip can be held with fine-point tweezers and supported underneath by the scalpel blade during placement on the microscope slide. The analyst can place several such strips on the same microscope slide, taking care to rinse and wet-wipe the scalpel blade and tweezers before handling a new sample. The filter strips should be identified by etching the glass slide or marking the slide using a marker insoluble in water and solvents. After the filter strip has been cut from each filter, the residual parts of the filter must be returned to the cassette and held in position by reassembly of the cassette. The cassette will then be archived for a period of 30 days or returned to the client upon request.

e. Carbon coating of filter strips. The glass slide holding the filter strips is placed on the rotation-tilting device, and the evaporator chamber is evacuated. The evaporation must be performed in very short bursts, separated by some seconds to allow the electrodes to cool. If evaporation is too rapid, the strips of polycarbonate filter will begin to curl, which will lead to cross-linking of the surface material and make it relatively insoluble in chloroform. An experienced analyst can judge the thickness of carbon film to be applied, and some test should be made first on unused filters. If the film is too thin, large particles will be lost from the TEM specimen, and there will be few complete and undamaged grid openings on the specimen. If the coating is too thick, the filter will tend to curl when exposed to chloroform vapor and the carbon film may not adhere to the support mesh. Too thick a carbon film will also lead to a TEM image that is lacking in contrast, and the ability to obtain ED patterns will be compromised. The carbon film should be as thin as possible and remain intact on most of the grid openings of the TEM specimen intact.

f. Preparation of the Jaffe washer. The precise design of the Jaffe washer is not considered important, so any one of the published designs may be used. A washer consisting of a simple stainless steel bridge is recommended. Several pieces of lens tissue approximately 1.0 cm x 0.5 cm are placed on the stainless steel bridge, and the washer is filled with chloroform to a level where the meniscus contacts the underside of the mesh, which results in saturation of the lens tissue. See References 8 and 10 of Unit III.L.

g. Placing of specimens into the Jaffe washer. The TEM grids are first placed on a piece of lens tissue so that individual grids can be picked up with tweezers. Using a curved scalpel blade, the analyst excises three 3 mm square pieces of the carbon-coated polycarbonate filter from the filter strip. The three squares are selected from the center of the strip and from two points between the outer periphery of the active surface and the center. The piece of filter is placed on a TEM specimen grid with the shiny side of the TEM grid facing upwards, and the whole assembly is placed boldly onto the saturated lens tissue in the Jaffe washer. If carbon-coated grids are used, the filter should be placed carbon-coated side down. The three excised squares of filters are placed on the same piece of lens tissue. Any number of separate pieces of lens tissue may be placed in the same Jaffe washer. The lid is then placed on the Jaffe washer, and the system is allowed to stand for several hours, preferably overnight.

h. *Condensation washing*. It has been found that many polycarbonate filters will not dissolve completely in the Jaffe washer, even after being exposed to chloroform for as long as 3 days. This problem becomes more serious if the surface of the filter was overheated during the carbon evaporation. The presence of undissolved filter medium on the TEM preparation leads to partial or complete obscuration of areas of the sample, and fibers that may be present in these areas of the specimen will be overlooked; this will lead to a low result. Undissolved filter medium also compromises the ability to obtain ED patterns. Before they are counted, TEM grids must be examined critically to determine whether they are adequately cleared of residual filter medium. It has been found that condensation washing of the grids after the initial Jaffe washer treatment, with chloroform as the solvent, clears all residual filter medium in a period of approximately 1 hour. In practice, the piece of lens tissue supporting the specimen grids is transferred to the cold finger of the condensation washer, and the washer is operated for about 1 hour. If the specimens are cleared satisfactorily by the Jaffe washer alone, the condensation washer step may be unnecessary.

8. TEM specimen preparation from MCE filters.

a. This method of preparing TEM specimens from MCE filters is similar to that specified in NIOSH Method 7402. See References 7, 8, and 9 of Unit III.L.

b. Upon receipt at the analytical laboratory, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces before entering the clean sample preparation area.

c. Remove a section from any quadrant of the sample and blank filters.

d. Place the section on a clean microscope slide. Affix the filter section to the slide with a gummed paged reinforcement or other suitable means. Label the slide with a water and solvent-proof marking pen.

e. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 minutes for the sample filter to fuse and clear.

f. Plasma etching of the collapsed filter is required.

i. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. This is one area of the method that requires further evaluation. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for a particular asher and operating conditions will then be set such that a 1-2 μm (10 percent) layer of collapsed surface will be removed.

ii. Place the slide containing the collapsed filters into a low-temperature plasma asher, and etch the filter.

g. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1 mm x 5 mm section of graphite rod onto the cleared filter. Remove the slide to a clean, dry, covered petri dish.

h. Prepare a second petri dish as a Jaffe washer with the wicking substrate prepared from filter or lens paper placed on top of a 6 mm thick disk of clean spongy polyurethane foam. Cut a V-notch on the edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent. The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

i. Place carbon-coated TEM grids face up on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish lid and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated. The level of acetone should be just high enough to saturate the filter paper without creating puddles.

j. Remove about a quarter section of the carbon-coated filter samples from the glass slides using a surgical knife and tweezers. Carefully place the section of the filter, carbon side down, on the appropriately labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to bring the acetone level up to the highest possible level without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it. This allows drops of condensed solvent vapors to form near the edge rather than in the center where they would drip onto the grid preparation. G. TEM Method

1. *Instrumentation.*

a. Use an 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely (see Unit III.J.) for magnification and camera constant.

b. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory. This must be an Energy Dispersive X-ray Detector mounted on TEM column and associated hardware/software to collect, save, and read out spectral information. Calibration of Multi-Channel Analyzer shall be checked regularly for Al at 1.48 KeV and Cu at 8.04 KeV, as well as the manufacturer's procedures.

i. Standard replica grating may be used to determine magnification (e.g., 2160 lines/mm).

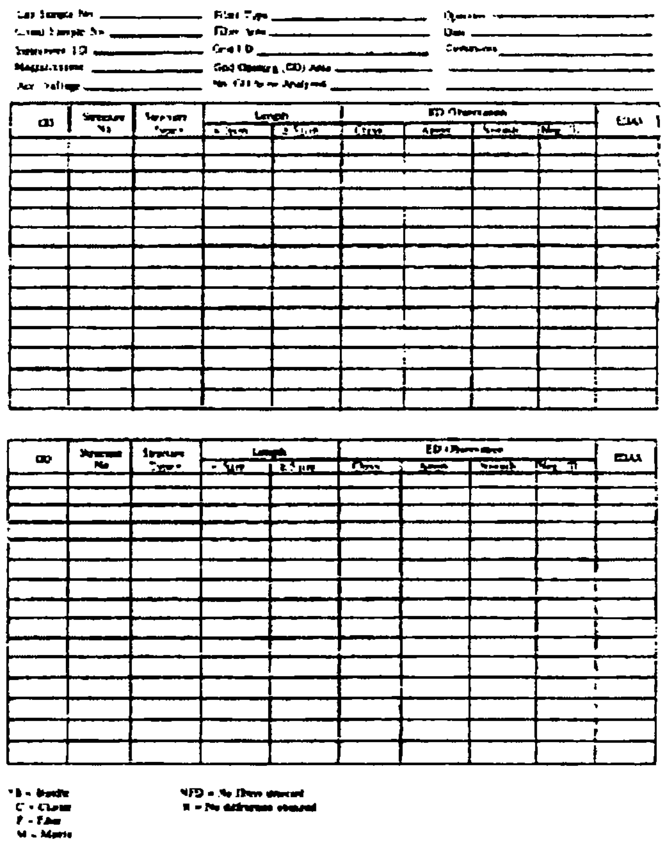
ii. Gold standard may be used to determine camera constant.

c. Use a specimen holder with single tilt and/or double tilt capabilities.

2. Procedure.

a. Start a new Count Sheet for each sample to be analyzed. Record on count sheet: analyst's initials and date; lab sample number; client sample number microscope identification; magnification for analysis; number of predetermined grid openings to be analyzed; and grid identification. See the following Figure 4:

FIGURE 4—COUNT SHEET



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b. Check that the microscope is properly aligned and calibrated according to the manufacturer's specifications and instructions.

c. Microscope settings: 80-120 kV, grid assessment 250-1000X, then 15,000-20,000X screen magnification for analysis.

d. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

e. Determine the suitability of the grid.

i. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading shall not be analyzed.

ii. Examine the grid at low magnification (<1000X) to determine its suitability for detailed study at higher magnifications.

iii. Reject the grid if:

(1) Less than 50 percent of the grid openings covered by the replica are intact.

(2) It is doubled or folded.

(3) It is too dark because of incomplete dissolution of the filter.

iv. If the grid is rejected, load the next sample grid.

v. If the grid is acceptable, continue on to Step 6 if mapping is to be used; otherwise proceed to Step 7.

f. Grid Map (Optional).

i. Set the TEM to the low magnification mode.

ii. Use flat edge or finder grids for mapping.

iii. Index the grid openings (fields) to be counted by marking the acceptable fields for one-half (0.5) of the area needed for analysis on each of the two grids to be analyzed. These may be marked just before examining each grid opening (field), if desired.

iv. Draw in any details which will allow the grid to be properly oriented if it is reloaded into the microscope and a particular field is to be reliably identified.

g. Scan the grid.

i. Select a field to start the examination.

ii. Choose the appropriate magnification (15,000 to 20,000X screen magnification).

iii. Scan the grid as follows.

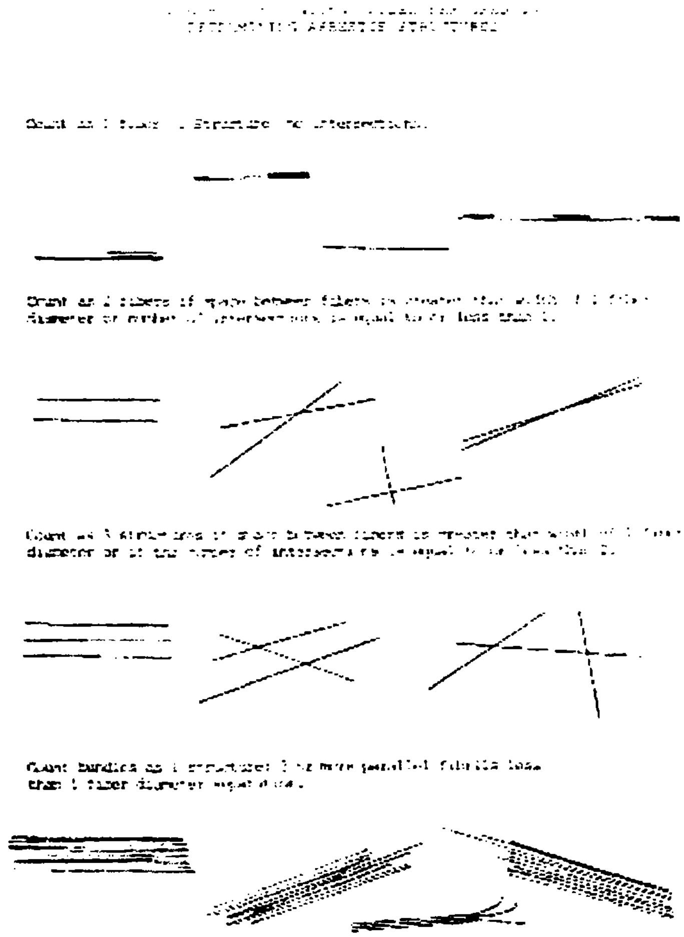
(1) At the selected magnification, make a series of parallel traverses across the field. On reaching the end of one traverse, move the image one window and reverse the traverse.

Note: A slight overlap should be used so as not to miss any part of the grid opening (field).

(2) Make parallel traverses until the entire grid opening (field) has been scanned.

h. Identify each structure for appearance and size.

i. Appearance and size: Any continuous grouping of particles in which an asbestos fiber within aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 μm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. See the following Figure 5:



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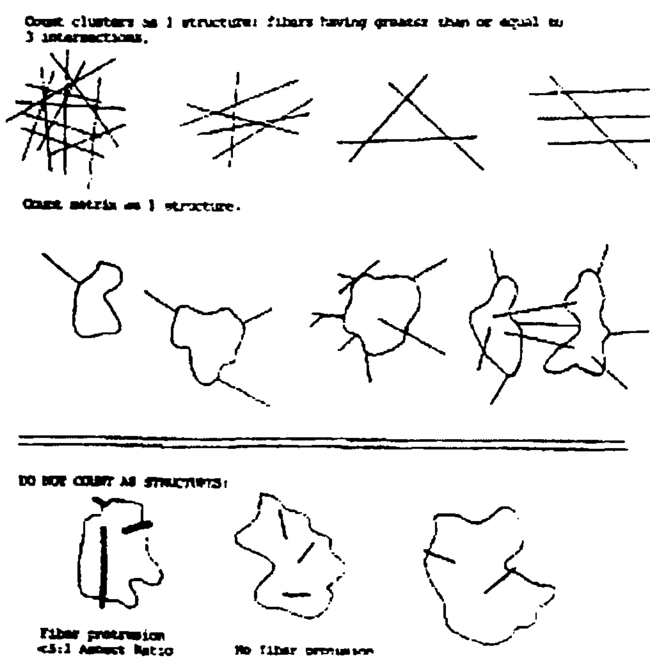

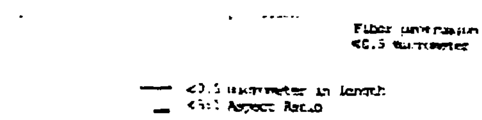

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An intersection is a non-parallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. Combinations such as a matrix and cluster, matrix and bundle, or bundle and cluster are categorized by the dominant fiber quality -- cluster, bundle, and matrix, respectively. Separate categories will be maintained for fibers less than 5 µm and for fibers greater than or equal to 5 µm in length. Not required, but useful, may be to record the fiber length in 1 µm intervals. (Identify each structure morphologically and analyze it as it enters the "window".)

(1) *Fiber.* A structure having a minimum length greater than 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed, no intersections.

(2) *Bundle.* A structure composed of 3 or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

(3) *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group; groupings must have more than 2 intersections.

(4) *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

(5) *NSD.* Record NSD when no structures are detected in the field.

(6) *Intersection.* Non-parallel touching or crossing of fibers, with the projection having an aspect ratio 5:1 or greater.

ii. Structure Measurement.

(1) Recognize the structure that is to be sized.

(2) Memorize its location in the "window" relative to the sides, inscribed square and to other particulates in the field so this exact location can be found again when scanning is resumed.

(3) Measure the structure using the scale on the screen.

(4) Record the length category and structure type classification on the count sheet after the field number and fiber number.

(5) Return the fiber to its original location in the window and scan the rest of the field for other fibers; if the direction of travel is not remembered, return to the right side of the field and begin the traverse again.

i. Visual identification of Electron Diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm 2 concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

i. Center the structure, focus, and obtain an ED pattern. (See Microscope Instruction Manual for more detailed instructions.)

ii. From a visual examination of the ED pattern, obtained with a short camera length, classify the observed structure as belonging to one of the following classifications: chrysotile, amphibole, or nonasbestos.

(1) Chrysotile: The chrysotile asbestos pattern has characteristic streaks on the layer lines other than the central line and some streaking also on the central line. There will be spots of normal sharpness on the central layer line and on alternate lines (2nd, 4th, etc.). The repeat distance between layer lines is 0.53 nm and the center doublet is at 0.73 nm. The pattern should display (002), (110), (130) diffraction maxima; distances and geometry should match a chrysotile pattern and be measured semiquantitatively.

(2) Amphibole Group [includes grunerite (amosite), crocidolite, anthophyllite, tremolite, and actinolite]: Amphibole asbestos fiber patterns show layer lines formed by very closely spaced dots, and the repeat distance between layer lines is also about 0.53 nm. Streaking in layer lines is occasionally present due to crystal structure defects.

(3) Nonasbestos: Incomplete or unobtainable ED patterns, a nonasbestos EDXA, or a nonasbestos morphology.

iii. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns. In the event that examination of the pattern by the qualified individual indicates that the pattern had been misidentified visually, the client shall be contacted. If the pattern is a suspected chrysotile, take a photograph of the diffraction pattern at 0 degrees tilt. If the structure is suspected to be amphibole, the sample may have to be tilted to obtain a simple geometric array of spots.

j. Energy Dispersive X-Ray Analysis (EDXA).

i. Required of all amphiboles which would cause the analysis results to exceed the 70 s/mm 2 concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

ii. Can be used alone to confirm chrysotile after the 70 s/mm 2 concentration has been exceeded.

iii. Can be used alone to confirm all nonasbestos.

iv. Compare spectrum profiles with profiles obtained from asbestos standards. The closest match identifies and categorizes the structure.

v. If the EDXA is used for confirmation, record the properly labeled spectrum on a computer disk, or if a hard copy, file with analysis data.

vi. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm 2 concentration, their identities must be confirmed by EDXA or measurement of a zone axis diffraction pattern to establish that the particles are nonasbestos.

k. Stopping Rules.

i. If more than 50 asbestiform structures are counted in a particular grid opening, the analysis may be terminated.

ii. After having counted 50 asbestiform structures in a minimum of 4 grid openings, the analysis may be terminated. The grid opening in which the 50th fiber was counted must be completed.

iii. For blank samples, the analysis is always continued until 10 grid openings have been analyzed.

iv. In all other samples the analysis shall be continued until an analytical sensitivity of 0.005 s/cm 3 is reached.

l. Recording Rules. The count sheet should contain the following information:

i. Field (grid opening): List field number.

ii. Record "NSD" if no structures are detected.

iii. Structure information.

(1) If fibers, bundles, clusters, and/or matrices are found, list them in consecutive numerical order, starting over with each field.

(2) Length. Record length category of asbestos fibers examined. Indicate if less than 5 µm or greater than or equal to 5 µm.

(3) Structure Type. Positive identification of asbestos fibers is required by the method. At least one diffraction pattern of each fiber type from every five samples must be recorded and compared with a standard diffraction pattern. For each asbestos fiber reported, both a morphological descriptor and an identification descriptor shall be specified on the count sheet.

(4) Fibers classified as chrysotile must be identified by diffraction and/or X-ray analysis and recorded on the count sheet. X-ray analysis alone can be used as sole identification only after 70s/mm 2 have been exceeded for a particular sample.

(5) Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used as sole identification only after 70s/mm 2 have been exceeded for a particular sample.)

(6) If a diffraction pattern was recorded on film, the micrograph number must be indicated on the count sheet.

count sheet.

(7) If an electron diffraction was attempted and an appropriate spectra is not observed, N should be recorded on the count sheet.

(8) If an X-ray analysis is attempted but not observed, N should be recorded on the count sheet.

(9) If an X-ray analysis spectrum is stored, the file and disk number must be recorded on the count sheet.

m. Classification Rules.

i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

v. *NSD.* Record NSD when no structures are detected in the field.

n. After all necessary analyses of a particle structure have been completed, return the goniometer stage to 0 degrees, and return the structure to its original location by recall of the original location.

o. Continue scanning until all the structures are identified, classified and sized in the field.

p. Select additional fields (grid openings) at low magnification; scan at a chosen magnification (15,000 to 20,000X screen magnification); and analyze until the stopping rule becomes applicable.

q. Carefully record all data as they are being collected, and check for accuracy.

r. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid hold. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. H. Sample Analytical Sequence

1. Carry out visual inspection of work site prior to air monitoring.

2. Collect a minimum of five air samples inside the work site and five samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

3. Analyze the abatement area samples according to this protocol. The analysis must meet the 0.005 s/cm 3 analytical sensitivity.

4. Remaining steps in the analytical sequence are contained in Unit IV. of this Appendix. I. Reporting

The following information must be reported to the client. See the following Table II:

TABLE II--EXAMPLE LABORATORY LETTERHEAD

Laboratory ID	Client ID	FILTER MEDIA DATA				Analyzed Area mm²	Sample Volume, cc
		Type	Diameter mm	Effective area, mm²	Pore Size µm		

INDIVIDUAL ANALYTICAL RESULTS

Laboratory ID	Client ID	# Asbestos Structures	Analytical Sensitivity, s/cc	CONCENTRATION	
				Structures/mm²	Structures/cc

The analysis was carried out to the approved TEM method. This laboratory is in compliance with the quality specified by the method.

Authorized Signature

View or Download PDF

1. Concentration in structures per square millimeter and structures per cubic centimeter.

2. Analytical sensitivity used for the analysis.

3. Number of asbestos structures.

4. Area analyzed.

5. Volume of air samples (which was initially provided by client).

6. Average grid size opening.

7. Number of grids analyzed.

8. Copy of the count sheet must be included with the report.

9. Signature of laboratory official to indicate that the laboratory met specifications of the AHERA method.

10. Report form must contain official laboratory identification (e.g., letterhead).

11. Type of asbestos. J. Calibration Methodology

Note: Appropriate implementation of the method requires a person knowledgeable in electron diffraction and mineral identification by ED and EDXA. Those inexperienced laboratories wishing to develop capabilities may acquire necessary knowledge through analysis of appropriate standards and by following detailed methods as described in References 8 and 10 of Unit III.L.

1. *Equipment Calibration.* In this method, calibration is required for the air-sampling equipment and the transmission electron microscope (TEM).

a. *TEM Magnification.* The magnification at the fluorescent screen of the TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica. A logbook must be maintained, and the dates of calibration depend on the past history of the particular microscope; no frequency is specified. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate an eucentric tilting specimen stage, all speciments and the cross grating replica must be placed at the eucentric position.

b. Determination of the TEM magnification on the fluorescent screen.

i. Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric).

ii. Insert a diffraction grating replica (for example a grating containing 2,160 lines/mm) into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that the goniometer stage tilt is 0 degrees.

iii. Adjust microscope magnification to 10,000X or 20,000X. Measure the distance (mm) between two widely separated lines on the grating replica. Note the number of spaces between the lines. Take care to measure between the same relative positions on the lines (e.g., between left edges of lines).

Note: The more spaces included in the measurement, the more accurate the final calculation. On most microscopes, however, the magnification is substantially constant only within the central 8-10 cm diameter region of the fluorescent screen.

iv. Calculate the true magnification (M) on the fluorescent screen:

M XG/Y

M=XG/Y

where:

X=total distance (mm) between the designated grating lines;

G=calibration constant of the grating replica (lines/mm):

Y=number of grating replica spaces counted along X.

c. Calibration of the EDXA System. Initially, the EDXA system must be calibrated by using two reference elements to calibrate the energy scale of the instrument. When this has been completed in accordance with the manufacturer's instructions, calibration in terms of the different types of asbestos can proceed. The EDXA detectors vary in both solid angle of detection and in window thickness. Therefore, at a particular accelerating voltage in use on the TEM, the count rate obtained from specific dimensions of fiber will vary both in absolute X-ray count rate and in the relative X-ray peak heights for different elements. Only a few minerals are relevant for asbestos abatement work, and in this procedure the calibration is specified in terms of a "fingerprint" technique. The EDXA spectra must be recorded from individual fibers of the relevant minerals, and identifications are made on the basis of semiquantitative comparisons with these reference spectra.

d. Calibration of Grid Openings.

i. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass slide and examining it under the PCM. Use a calibrated graticule to measure the average field diameter and use this number to calculate the field area for an average grid opening. Grids are to be randomly selected from batches up to 1,000.

Note: A grid opening is considered as one field.

ii. The mean grid opening area must be measured for the type of specimen grids in use. This can be accomplished on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

e. Determination of Camera Constant and ED Pattern Analysis.

i. The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film.

ii. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulates. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one half the diameter constant using multiple gold rings can be determined. The camera constant is one-half the diameter, D, of the rings times the interplanar spacing, d, of the ring being measured. K. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III—SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	90% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks and special testing after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results.

If this average is greater than 53 f/mm ^{2} per 10 200-mesh grid openings, check the system for possible sources of contamination.

6. Check for recovery of asbestos from cellulose ester filters submitted to plasma asher.

7. Check for asbestos carryover in the plasma asher by including a blank alongside the positive control sample.

8. Perform a systems check on the transmission electron microscope daily.

9. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III of Unit III.K.

10. Ensure qualified operator performance by evaluation of replicate counting, duplicate analysis, and standard sample comparisons as set forth in Table III of Unit III.K.

11. Validate all data entries.

12. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III.

13. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The outline of quality control procedures presented above is viewed as the minimum required to assure that quality data is produced for clearance testing of an asbestos abated area. Additional information may be gained by other control tests. Specifics on those control procedures and options available for environmental testing can be obtained by consulting References 6, 7, and 11 of Unit III.L. L. References

For additional background information on this method the following references should be consulted.

1. "Guidelines for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.

2. "Measuring Airborne Asbestos Following an Abatement Action," USEP/Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.

3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619. 1982.

4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.

5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume Through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Burdett, G.J. Health & Safety Exec., Research & Lab. Services Div., London, "Proposed

7. Burdette, G.J. Health & Safety Exec., Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc. "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters." WERL SOP 87-1, March 5, 1987.

9. NIOSH. Method 7402 for Asbestos Fibers, December 11, 1986 Draft.

10. Yamate, G., S.C. Agarwall, R.D. Gibbons, IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy." Draft report, USEPA Contract 68-02-3266, July 1984.

11. Guidance to the Preparation of Quality Assurance Project Plans. USEPA, Office of Pollution Prevention and Toxics, 1984.

IV. Mandatory Interpretation of Transmission Electron Microscopy Results to Determine Completion of Response Actions

A. Introduction

A response action is determined to be completed by TEM when the abatement area has been cleaned and the airborne asbestos concentration inside the abatement area is no higher than concentrations at locations outside the abatement area. "Outside" means outside the abatement area, but not necessarily outside the building. EPA reasons that an asbestos removal contractor cannot be expected to clean an abatement area to an airborne asbestos concentration that is lower than the concentration of air entering the abatement area from outdoors or from other parts of the building. After the abatement area has passed a thorough visual inspection, and before the outer containment barrier is removed, a minimum of five air samples inside the abatement area and a minimum of five air samples outside the abatement area must be collected. Hence, the response action is determined to be completed when the average airborne asbestos concentration measured inside the abatement area is not statistically different from the average airborne asbestos concentration measured outside the abatement area.

The inside and outside concentrations are compared by the Z-test, a statistical test that takes into account the variability in the measurement process. A minimum of five samples inside the abatement area and five samples outside the abatement area are required to control the false negative error rate, i.e., the probability of declaring the removal complete when, in fact, the air concentration inside the abatement area is significantly higher than outside the abatement area. Additional quality control is provided by requiring three blanks (filters through which no air has been drawn) to be analyzed to check for unusually high filter contamination that would distort the test results.

When volumes greater than or equal to 1,199 L for a 25 mm filter and 2,799 L for a 37 mm filter have been collected and the average number of asbestos structures on samples inside the abatement area is no greater than 70 s/mm ^{2} of filter, the response action may be considered complete without comparing the inside samples to the outside samples. EPA is permitting this initial screening test to save analysis costs in situations where the airborne asbestos concentration is sufficiently low so that it cannot be distinguished from the filter contamination/background level (fibers deposited on the filter that are unrelated to the air being sampled). The screening test cannot be used when volumes of less than 1,199 L for 25 mm filter or 2,799 L for a 37 mm filter are collected because the ability to distinguish levels significantly different from filter background is collected because the ability to distinguish levels significantly different from filter background is reduced at low volumes.

The initial screening test is expressed in structures per square millimeter of filter because filter background levels come from sources other than the air being sampled and cannot be meaningfully expressed as a concentration per cubic centimeter of air. The value of 70 s/mm 2 is based on the experience of the panel of microscopists who consider one structure in 10 grid openings (each grid opening with an area of 0.0057 mm 2) to be comparable with contamination/background levels of blank filters. The decision is based, in part, on Poisson statistics which indicate that four structures must be counted on a filter before the fiber count is statistically distinguishable from the count for one structure. As more information on the performance of the method is collected, this criterion may be modified. Since different combinations of the number and size of grid openings are permitted under the TEM protocol, the criterion is expressed in structures per square millimeter of filter to be consistent across all combinations. Four structures per 10 grid openings corresponds to approximately 70 s/mm 2. B. Sample Collection and Analysis

1. A minimum of 13 samples is required: five samples collected inside the abatement area, five samples collected outside the abatement area, two field blanks, and one sealed blank.

2. Sampling and TEM analysis must be done according to either the mandatory or nonmandatory protocols in Appendix A. At least 0.057 mm 2 of filter must be examined on blank filters. C. Interpretation of Results

1. The response action shall be considered complete if either:

a. Each sample collected inside the abatement area consists of at least 1,199 L of air for a 25 mm filter, or 2,799 L of air for a 37 mm filter, and the arithmetic mean of their asbestos structure concentrations per square millimeter of filter is less than or equal to 70 s/mm 2; or

b. The three blank samples have an arithmetic mean of the asbestos structure concentration on the blank filters that is less than or equal to 70 s/mm 2 and the average airborne asbestos concentration measured inside the abatement area is not statistically higher than the average airborne asbestos concentration measured outside the abatement area as determined by the Z-test. The Z-test is carried out by calculating

$$Z = \frac{\bar{Y}_I - \bar{Y}_O}{0.8(1/n_I + 1/n_O)^{1/2}}$$

where YI is the average of the natural logarithms of the inside samples and YO is the average of the natural logarithms of the outside samples, nI is the number of inside samples and nO is the number of outside samples. The response action is considered complete if Z is less than or equal to 1.65.

Note: When no fibers are counted, the calculated detection limit for that analysis is inserted for the concentration.

2. If the abatement site does not satisfy either (1) or (2) of this Section C, the site must be recleaned and a new set of samples collected. D. Sequence for Analyzing Samples

It is possible to determine completion of the response action without analyzing all samples. Also, at any point in the process, a decision may be made to terminate the analysis of existing samples any point in the process, a decision may be made to terminate the analysis of existing samples, reclean the abatement site, and collect a new set of samples. The following sequence is outlined to minimize the number of analyses needed to reach a decision.

1. Analyze the inside samples.

2. If at least 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for each inside sample and the arithmetic mean concentration of structures per square millimeter of filter is less than or equal to 70 s/mm 2, the response action is complete and no further analysis is needed.

3. If less than 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for any of the inside samples, or the arithmetic mean concentration of structures per square millimeter of filter is greater than 70 s/mm 2, analyze the three blanks.

4. If the arithmetic mean concentration of structures per square millimeter on the blank filters is greater than 70 s/mm 2, terminate the analysis, identify and correct the source of blank contamination, and collect a new set of samples.

5. If the arithmetic mean concentration of structures per square millimeter on the blank filters is less than or equal to 70 s/mm 2, analyze the outside samples and perform the Z-test.

6. If the Z-statistic is less than or equal to 1.65, the response action is complete. If the Z-statistic is greater than 1.65, reclean the abatement site and collect a new set of samples.

[52 FR 41857, Oct. 30, 1987]

Appendix C
Air Sampling

EPA Guidelines SOP 2008 - General Air Sampling

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments[1,2,3]. Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents[4].

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- Emergency Response

  Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- Removal Site Assessment

  Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- Removal Actions

  Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bagsor culture tubes) which are then placed into a shipping container.

Use bubble wrap or styrofoam peanuts when packing air samples for shipment. DO NOT USE VERMICULITE.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; volatile compounds from petrochemical facilities; and effluvium from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons

(PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites[5]," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical methods for sampling: *NIOSH Manual of Analytical Methods*[6], *American Society for Testing and Materials (ASTM) Methods*[7], *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*[8,9], and *OSHA Methods*[10]. Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)[11] and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*[12]. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon® tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels

- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height, provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.

- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.

- One-time: only one chance is given to collect a sample without regard to time or conditions.

Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and costlimitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.

- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.

- Topographic features that affect the dispersion and transport of airborne toxic constituents.

Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.

- Roadways (dirt or paved), which may generate dust that could mask site contaminants.

- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate, especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. Often, a number of alternatives can fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. Ocean/lake effects may require a radical plan to collect enough samples to reach a low detection limit. Two sets of samplers may be placed next to each other: one set would be activated during the sea breeze while the other set is turned off, and vice versa when there is no sea breeze. After the sampling event, the respective upwind and downwind samples would be combined. Another alternative for sampling near a large body of water may be to use automatic, wind-vector-operated samplers, which turn the sampler on only when the wind comes from a specified vector. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to ring the site to measure the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data. Also, additional upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors in sampler location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 VAC electric power. When portable generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

- Wind Speed

  When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

- Wind Direction

  Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- Atmospheric Stability

  Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

- Temperature

  Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

- Humidity

  High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase the detection limit.

- Atmospheric Pressure

  Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

  In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

  The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITYASSURANCE/ QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

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APPENDIX A

Portable Screening Devices and Specialized Analytical Instruments

PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

- Total Hydrocarbon Analyzers

  Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

- Oxygen and Combustible Gas Indicators

  Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL).

The measurements are temperature-dependent. The property of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH *Pocket Guide to Chemical Hazards*. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e, O_2 content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

- Toxic Atmosphere Analyzers

  The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may be lead to erroneous results.

  U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- Aerosol/Particulate Monitors

  A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

  The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- Chemical Detector Tubes (Colorimetric Tubes)

  A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- Radiation Meters

  Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

  Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- Infrared Detectors

  Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.

SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- Direct Air Sampling Portable Gas Chromatographs (GCs)

  Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

  This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

  The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.

APPENDIX B

Air Sampling Equipment and Media/Devices

AIR SAMPLING EQUIPMENT

- High-Volume, Total Suspended Particulate (TSP) Samplers

  High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

- PM-10 Samplers

  PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon filters.

- High-Volume PS-1 Samplers

  High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

  These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

- Personal Sampling Pumps

  Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.

- Canister Samplers

  Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control device until the canister is near atmospheric pressure.

  Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

- Summa® Canisters

  Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

- Passive Dosimeters

  Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- Polyurethane Foam (PUF)

  PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

- Sampling Bags (Tedlar®)

  Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO_2, O_2 and N_2) and methane.

- Impingers

  An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- Sorbent Tubes/Cartridges

  A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

- Tenax Tubes

  Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

- Carbonized Polymers

  The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- Mixed Sorbent Tubes

  Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- Chemically Treated Silica Gel

  Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

- XAD-2 Polymers

  XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- Charcoal Cartridges

  Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

  Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

  MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

  Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

  Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon

  Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

  Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

  Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.

Appendix D
Personal Breathing Zone Air Collection Procedures

U.S. Department of Labor OSHA 1926.1101. Appendix B - Appendix B to Subpart Z of Part 1926, Sampling and Analysis - Non- mandatory

Regulations (Standards - 29 CFR)

Sampling and Analysis - Non-mandatory - 1926.1101 App B

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** Z
- **Subpart Title:** Toxic and Hazardous Substances
- **Standard Number:** 1926.1101 App B
- **Title:** Sampling and Analysis - Non-mandatory

```
                                                  Matrix

Matrix:
 OSHA Permissible Exposure Limits:
   Time Weighted Average.........................  0.1 fiber/cc
   Excursion Level (30 minutes)..................  1.0 fiber/cc
Collection Procedure:
A known volume of air is drawn through a 25-mm diameter cassette
   containing a mixed-cellulose ester filter. The cassette must be
   equipped with an electrically conductive 50-mm extension cowl.
   The sampling time and rate are chosen to give a fiber density of
   between 100 to 1,300 fibers/mm2 on the filter.
```

```
Recommended Sampling Rate......................  0.5 to 5.0 liters/
                                                    minute (L/min)
Recommended Air Volumes:
 Minimum......................................  25 L
 Maximum......................................  2,400 L
```

Analytical Procedure:

A portion of the sample filter is cleared and prepared for asbestos fiber counting by Phase Contrast Microscopy (PCM) at 400X.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

1. Introduction

This method describes the collection of airborne asbestos fibers using calibrated sampling pumps with mixed-cellulose ester (MCE) filters and analysis by phase contrast microscopy (PCM). Some terms used are unique to this method and are defined below: Asbestos: A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, crocidolite, amosite (cummingtonite-grunerite asbestos), tremolite asbestos, actinolite asbestos, anthophyllite asbestos, and any of these minerals that have been chemically treated and/or altered. The precise chemical formulation of each species will vary with the location from which it was mined. Nominal compositions are listed:

```
Chrysotile................  Mg(3)Si(2)O(5)(OH)(4)
Crocidolite...............  Na(2)Fe(3)(2)+Fe(2)(3)+Si(8)O(22)(OH)(2)
Amosite...................  (Mg,Fe)(7)Si(8)O(22)(OH)(2)
Tremolite-actinolite......  Ca(2)(Mg,Fe)(5)Si(8)O(22)(OH)(2)
Anthophyllite.............  (Mg,Fe)(7)Si(8)O(22)(OH)(2)
```

Asbestos Fiber: A fiber of asbestos which meets the criteria specified below for a fiber.

Aspect Ratio: The ratio of the length of a fiber to it's diameter (e.g. 3:1, 5:1 aspect ratios).

Cleavage Fragments: Mineral particles formed by comminution of minerals, especially those characterized by parallel sides and a moderate aspect ratio (usually less than 20:1).

Detection Limit: The number of fibers necessary to be 95% certain that the result is greater than zero.

Differential Counting: The term applied to the practice of excluding certain kinds of fibers from the fiber count because they do not appear to be asbestos.

Fiber: A particle that is 5 um or longer, with a length-to-width ratio of 3 to 1 or longer.

Field: The area within the graticule circle that is superimposed on the microscope image.

Set: The samples which are taken, submitted to the laboratory, analyzed, and for which, interim or final result reports are generated.

Tremolite, Anthophyllite, and Actinolite: The non-asbestos form of these minerals which meet the definition of a fiber. It includes any of these minerals that have been chemically treated and/or altered.

Walton-Beckett Graticule: An eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a projected diameter of 100 plus or minus 2 um (area of about 0.00785 mm(2)) with a crosshair having tic-marks at 3-um intervals in one direction and 5-um in the orthogonal direction. There are marks around the periphery of the circle to demonstrate the proper sizes and shapes of fibers. This design is reproduced in Figure 1. The disk is placed in one of the microscope eyepieces so that the design is superimposed on the field of view.

1.1. History

Early surveys to determine asbestos exposures were conducted using impinger counts of total dust with the counts expressed as million particles per cubic foot. The British Asbestos Research Council recommended filter membrane counting in 1969. In July 1969, the Bureau of Occupational Safety and Health published a filter membrane method for counting asbestos fibers in the United States. This method was refined by NIOSH and published as P & CAM 239. On May 29, 1971, OSHA specified filter membrane sampling with phase contrast counting for evaluation of asbestos exposures at work sites in the United States. The use of this technique was again required by OSHA in 1986. Phase contrast microscopy has continued to be the method of choice for the measurement of occupational exposure to asbestos.

1.2. Principle

Air is drawn through a MCE filter to capture airborne asbestos fibers. A wedge shaped portion of the filter is removed, placed on a glass microscope slide and made transparent. A measured area (field) is viewed by PCM. All the fibers meeting defined criteria for asbestos are counted and considered a measure of the airborne asbestos concentration.

1.3. Advantages and Disadvantages

There are four main advantages of PCM over other methods:

(1) The technique is specific for fibers. Phase contrast is a fiber counting technique which excludes non-fibrous particles from the analysis.

(2) The technique is inexpensive and does not require specialized knowledge to carry out the analysis for total fiber counts.

(3) The analysis is quick and can be performed on-site for rapid determination of air concentrations of asbestos fibers.

(4) The technique has continuity with historical epidemiological studies so that estimates of expected disease can be inferred from long-term determinations of asbestos exposures.

The main disadvantage of PCM is that it does not positively identify asbestos fibers. Other fibers which are not asbestos may be included in the count unless differential counting is performed. This requires a great deal of experience to adequately differentiate asbestos from non-asbestos fibers. Positive identification of asbestos must be performed by polarized light or electron microscopy techniques. A further disadvantage of PCM is that the smallest visible fibers are about 0.2 um in diameter while the finest asbestos fibers may be as small as 0.02 um in diameter. For some exposures, substantially more fibers may be present than are actually counted.

1.4. Workplace Exposure

Asbestos is used by the construction industry in such products as shingles, floor tiles, asbestos cement, roofing felts, insulation and acoustical products. Non-construction uses include brakes, clutch facings, paper, paints, plastics, and fabrics. One of the most significant exposures in the workplace is the removal and encapsulation of asbestos in schools, public

TOUCH the filter with your finger. Place the filter on the glass slide sample side up. Static electricity will usually keep the filter on the slide until it is cleared.

6.5.5. Place the tip of the micropipette containing about 200 uL acetone into the aluminum block. Insert the glass slide into the receiving slot in the aluminum block. Inject the acetone into the block with slow, steady pressure on the plunger while holding the pipette firmly in place. Wait 3 to 5 seconds for the filter to clear, then remove the pipette and slide from the aluminum block.

6.5.6. Immediately (less than 30 seconds) place 2.5 to 3.5 uL of triacetin on the filter (NOTE: Waiting longer than 30 seconds will result in increased index of refraction and decreased contrast between the fibers and the preparation. This may also lead to separation of the cover slip from the slide).

6.5.7. Lower a cover slip gently onto the filter at a slight angle to reduce the possibility of forming air bubbles. If more than 30 seconds have elapsed between acetone exposure and triacetin application, glue the edges of the cover slip to the slide with lacquer or nail polish.

6.5.8. If clearing is slow, warm the slide for 15 min on a hot plate having a surface temperature of about 50 deg.C to hasten clearing. The top of the hot block can be used if the slide is not heated too long.

6.5.9. Counting may proceed immediately after clearing and mounting are completed.

6.6. Sample Analysis

Completely align the microscope according to the manufacturer's instructions. Then, align the microscope using the following general alignment routine at the beginning of every counting session and more often if necessary.

6.6.1. Alignment

(1) Clean all optical surfaces. Even a small amount of dirt can significantly degrade the image.

(2) Rough focus the objective on a sample.

(3) Close down the field iris so that it is visible in the field of view. Focus the image of the iris with the condenser focus. Center the image of the iris in the field of view.

(4) Install the phase telescope and focus on the phase rings. Critically center the rings. Misalignment of the rings results in astigmatism which will degrade the image.

(5) Place the phase-shift test slide on the microscope stage and focus on the lines. The analyst must see line set 3 and should see at least parts of 4 and 5 but, not see line set 6 or 6. A microscope/microscopist combination which does not pass this test may not be used.

6.6.2. Counting Fibers

(1) Place the prepared sample slide on the mechanical stage of the microscope. Position the

center of the wedge under the objective lens and focus upon the sample.

(2) Start counting from one end of the wedge and progress along a radial line to the other end (count in either direction from perimeter to wedge tip). Select fields randomly, without looking into the eyepieces, by slightly advancing the slide in one direction with the mechanical stage control.

(3) Continually scan over a range of focal planes (generally the upper 10 to 15 um of the filter surface) with the fine focus control during each field count. Spend at least 5 to 15 seconds per field.

(4) Most samples will contain asbestos fibers with fiber diameters less than 1 um. Look carefully for faint fiber images. The small diameter fibers will be very hard to see. However, they are an important contribution to the total count.

(5) Count only fibers equal to or longer than 5 um. Measure the length of curved fibers along the curve.

(6) Count fibers which have a length to width ratio of 3:1 or greater.

(7) Count all the fibers in at least 20 fields. Continue counting until either 100 fibers are counted or 100 fields have been viewed; whichever occurs first. Count all the fibers in the final field.

(8) Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle shall receive a count of 1/2. Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area. If a fiber touches the circle, it is considered to cross the line.

(9) Count bundles of fibers as one fiber unless individual fibers can be clearly identified and each individual fiber is clearly not connected to another counted fiber. See Figure 1 for counting conventions.

(10) Record the number of fibers in each field in a consistent way such that filter non-uniformity can be assessed.

(11) Regularly check phase ring alignment.

(12) When an agglomerate (mass of material) covers more than 25% of the field of view, reject the field and select another. Do not include it in the number of fields counted.

(13) Perform a "blind recount" of 1 in every 10 filter wedges (slides). Re-label the slides using a person other than the original counter.

6.7. Fiber Identification

As previously mentioned in Section 1.3., PCM does not provide positive confirmation of asbestos fibers. Alternate differential counting techniques should be used if discrimination is desirable. Differential counting may include primary discrimination based on morphology, polarized light analysis of fibers, or modification of PCM data by Scanning Electron or Transmission Electron Microscopy.

A great deal of experience is required to routinely and correctly perform differential counting. It is discouraged unless it is legally necessary. Then, only if a fiber is obviously not asbestos should it be excluded from the count. Further discussion of this technique can be found in reference 8.10.

If there is a question whether a fiber is asbestos or not, follow the rule:

"WHEN IN DOUBT, COUNT."

6.8. Analytical Recommendations -- Quality Control System

6.8.1. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos or an equivalent course.

6.8.2. Each laboratory engaged in asbestos counting shall set up a slide trading arrangement with at least two other laboratories in order to compare performance and eliminate inbreeding of error. The slide exchange occurs at least semiannually. The round robin results shall be posted where all analysts can view individual analyst's results.

6.8.3. Each laboratory engaged in asbestos counting shall participate in the Proficiency Analytical Testing Program, the Asbestos Analyst Registry or equivalent.

6.8.4. Each analyst shall select and count prepared slides from a "slide bank". These are quality assurance counts. The slide bank shall be prepared using uniformly distributed samples taken from the workload. Fiber densities should cover the entire range routinely analyzed by the laboratory. These slides are counted blind by all counters to establish an original standard deviation. This historical distribution is compared with the quality assurance counts. A counter must have 95% of all quality control samples counted within three standard deviations of the historical mean. This count is then integrated into a new historical mean and standard deviation for the slide.

The analyses done by the counters to establish the slide bank may be used for an interim quality control program if the data are treated in a proper statistical fashion.

7. Calculations

7.1. Calculate the estimated airborne asbestos fiber concentration on the filter sample using the following formula:

(For Equation A, Click Here)

where:

```
AC    = Airborne fiber concentration
FB    = Total number of fibers greater than 5 um counted
FL    = Total number of fields counted on the filter
BFB   = Total number of fibers greater than 5 um counted in the blank
```

```
BFL   = Total number of fields counted on the blank
ECA   = Effective collecting area of filter (385 mm(2) nominal for a
        25-mm filter.)
FR    = Pump flow rate (L/min)
MFA   = Microscope count field area (mm(2)). This is 0.00785 mm(2) for
        a Walton-Beckett Graticule.
T     = Sample collection time (min)
1,000 = Conversion of L to cc
```

```
 Note: The collection area of a filter is seldom equal to 385 mm(2). It
is appropriate for laboratories to routinely monitor the exact diameter
using an inside micrometer. The collection area is calculated according to
the formula:

Area = pi(d/2)(2)
```

7.2. Short-Cut Calculation

Since a given analyst always has the same interpupillary distance, the number of fields per filter for a particular analyst will remain constant for a given size filter. The field size for that analyst is constant (i.e. the analyst is using an assigned microscope and is not changing the reticle).

For example, if the exposed area of the filter is always 385 mm(2) and the size of the field is always 0.00785 mm(2) the number of fields per filter will always be 49,000. In addition it is necessary to convert liters of air to cc. These three constants can then be combined such that ECA/(1,000 x MFA) = 49. The previous equation simplifies to:

(For Equation B, Click Here)

7.3. Recount Calculations

As mentioned in step 13 of Section 6.6.2., a "blind recount" of 10% of the slides is performed. In all cases, differences will be observed between the first and second counts of the same filter wedge. Most of these differences will be due to chance alone, that is, due to the random variability (precision) of the count method. Statistical recount criteria enables one to decide whether observed differences can be explained due to chance alone or are probably due to systematic differences between analysts, microscopes, or other biasing factors.

The following recount criterion is for a pair of counts that estimate AC in fibers/cc. The criterion is given at the type-I error level. That is, there is 5% maximum risk that we will reject a pair of counts for the reason that one might be biased, when the large observed difference is really due to chance.

```
 Reject a pair of counts if:

(For Equation C, Click Here)

Where:

AC(1)    = lower estimated airborne fiber concentration
AC(2)    = higher estimated airborne fiber concentration
AC(avg)  = average of the two concentration estimates
```

CV(FB) = CV for the average of the two concentration estimates

If a pair of counts are rejected by this criterion then, recount the rest of the filters in the submitted set. Apply the test and reject any other pairs failing the test. Rejection shall include a memo to the industrial hygienist stating that the sample failed a statistical test for homogeneity and the true air concentration may be significantly different than the reported value.

7.4. Reporting Results

Report results to the industrial hygienist as fibers/cc. Use two significant figures. If multiple analyses are performed on a sample, an average of the results is to be reported unless any of the results can be rejected for cause.

8. References

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Quality Control

The OSHA asbestos regulations require each laboratory to establish a quality control program. The following is presented as an example of how the OSHA-SLTC constructed its internal CV curve as part of meeting this requirement. Data is from 395 samples collected during OSHA compliance inspections and analyzed from October 1980 through April 1986.

Each sample was counted by 2 to 5 different counters independently of one another. The standard deviation and the CV statistic was calculated for each sample. This data was then plotted on a graph of CV vs. fibers/mm(2). A least squares regression was performed using the following equation:

```
CV = antilog(10)[A(log(10)(x))(2)+B(log(10)(x))+C]

 where:

x = the number of fibers/mm(2)

 Application of least squares gave:

A = 0.182205
B = 0.973343
C = 0.327499

 Using these values, the equation becomes:

CV = antilog(10)[0.182205(log(10)(x))(2)-0.973343(log (10)(x))+0.327499]

Sampling Pump Flow Rate Corrections

 This correction is used if a difference greater than 5% in ambient
temperature and/or pressure is noted between calibration and sampling
sites and the pump does not compensate for the differences.

(For Equation D, Click Here)

Where:

Q(act) = actual flow rate
Q(cal) = calibrated flow rate (if a rotameter was used, the rotameter
         value)
P(cal) = uncorrected air pressure at calibration
P(act) = uncorrected air pressure at sampling site
T(act) = temperature at sampling site (K)
T(cal) = temperature at calibration (K)
```

Walton-Beckett Graticule

When ordering the Graticule for asbestos counting, specify the exact disc diameter needed to fit the ocular of the microscope and the diameter (mm) of the circular counting area. Instructions for measuring the dimensions necessary are listed:

(1) Insert any available graticule into the focusing eyepiece and focus so that the graticule lines are sharp and clear.

(2) Align the microscope.

(3) Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.

(4) Measure the magnified grid length, PL (um), using the stage micrometer.

(5) Remove the graticule from the microscope and measure its actual grid length, AL (mm). This can be accomplished by using a mechanical stage fitted with verniers, or a jeweler's loupe with a direct reading scale.

(6) Let D = 100 um. Calculate the circle diameter, d(c)(mm), for the Walton-Beckett graticule and specify the diameter when making a purchase:

$$d(c) = \frac{AL \times D}{PL}$$

```
Example:

If PL = 108 um, AL = 2.93 mm and D = 100 um,

then,
```

$$d(c) = \frac{2.93 \times 100}{108} = 2.71\text{mm}$$

(7) Each eyepiece-objective-reticle combination on the microscope must be calibrated. Should any of the three be changed (by zoom adjustment, disassembly, replacement, etc.), the combination must be recalibrated. Calibration may change if interpupillary distance is changed.

Measure the field diameter, D (acceptable range: 100 plus or minus 2 um) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine the field area (mm (2)).

```
Field Area = pi(D/2)(2)
If D = 100 um = 0.1 mm, then
Field Area = pi(0.1 mm/2)(2) = 0.00785 mm(2)
```

The Graticule is available from: Graticules Ltd., Morley Road, Tonbridge TN9 IRN, Kent, England (Telephone 011-44-732-359061). Also available from PTR Optics Ltd., 145 Newton Street, Waltham, MA 02154 [telephone (617) 891-6000] or McCrone Accessories and Components, 2506 S. Michigan Ave., Chicago, IL 60616 [phone (312)-842-7100]. The graticule is custom made for each microscope.

(For Figure 1 of Walton-Beckett Graticule, Click Here)

Counts for the Fibers in the Figure

Structure No.	Count	Explanation
1 to 6.......	1	Single fibers all contained within the Circle.
7............	1/2	Fiber crosses circle once.
8............	0	Fiber too short.
9............	2	Two crossing fibers.
10...........	0	Fiber outside graticule.
11...........	0	Fiber crosses graticule twice.
12...........	1/2	Although split, fiber only crosses once.

[60 FR 33972, June 29, 1995]

Next Standard (1926.1101 App C)

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Occupational Safety & Health Administration
200 Constitution Avenue, NW
Washington, DC 20210

Appendix B

Construction Specifications,
A&E Air Monitoring Frequencies, and
Small Scale Vermiculite Removals Technical Memorandum

Construction Specifications

Libby Asbestos Project
Libby, Montana

Construction Specifications
Libby Asbestos Project
Libby, Montana

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SECTION 1

CONTROL OF WORK

1.01 MATERIALS, EQUIPMENT, AND SUPPLIES

A. The removal contractor will furnish materials, equipment and supplies which will be efficient, appropriate and large enough to secure a satisfactory quality of work and rate of progress and ensure the completion of the work within the time stipulated in the contract.

1.02 OTHER OR ADJACENT LAND

A. The removal contractor shall not enter or occupy other or adjacent land except by written permission of the Volpe Center and approval from the property owner.

B. Access to work areas shall be restricted to the areas shown on the site-specific work plan and/or specified herein or as directed by the Volpe Center.

1.03 CARE AND PROTECTION OF PROPERTY

A. The removal contractor shall be responsible for the preservation of all public and private property, and use every precaution necessary to prevent damage thereto. If any direct or indirect damage is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work on the part of the removal contractor, such property shall be restored by the removal contractor, at their expense, to a condition similar or equal to that existing before the damage was done. Specifically included are asphalt and/or concrete paved areas used by the removal contractor as work areas or access ways.

1.04 HOUSEKEEPING

A. During the course of the work, the removal contractor shall keep the site of operations in as clean and neat a condition as is possible. The removal contractor shall dispose of all contaminated and non-contaminated waste material resulting from the work and, at the conclusion of the work shall ensure that the entire site is left in a neat and orderly condition.

B. As needed, but not less than daily, the removal contractor shall clean any portion of streets and roadways traversed by trucks hauling residential common fill, topsoil or structural fill to the site and remove any debris or material that may have accumulated during the course of daily operations.

1.05 SITE CONTROL

A. The removal contractor shall coordinate all entrance to and exit from the work areas, and any other related matters. The removal contractor shall be responsible for site control and the protection of his facilities and equipment 24 hours per day, and shall make no claim against the government. During working hours the removal contractor shall designate specific work site personnel for enforcing site control and restricting access.

B. Vehicular access to the site shall be restricted to authorized vehicles only.

C. The removal contractor shall be responsible for maintaining a log of security incidents for the duration of the work. Security incidents shall be reported to the Volpe Center immediately upon discovery.

D. The removal contractor shall require all employees having access to the site to sign-in and sign-out, and keep a record of all site access.

1.06 COMMUNICATIONS

A. Provide hard-line telephone communication at removal contractor's field office.

B. Emergency numbers, including police, fire, ambulance, hospital, and all others necessary shall be prominently posted near the telephone.

C. Provide two-way radio communication or cellular phone communication. The removal contractor shall have the ability to communicate between the field office and each active work location.

D. The removal contractor must ensure that 2-way radio communication is maintained between personnel in the Support Zone and Exclusion Zone.

1.07 EMERGENCY AND FIRST AID REQUIREMENTS

A. At least one industrial first aid kit, Model No. 8172 as manufactured by Johnson and Johnson Health Care Division, or approved equal, shall be provided at each active work area and maintained fully stocked.

B. The first aid kit location(s) shall be specially marked and provided with adequate water and other supplies necessary to cleanse and decontaminate burns, wounds, or lesions. First aid station(s) shall be supplied with buffer solution for treating acid and caustic burns.

C. The removal contractor shall provide 20A-80 B:C type dry chemical fire extinguishers at all work sites.

D. The removal contractor shall develop a contingency plan for the following possible emergencies: hazardous materials exposure, personal injury, potential or actual fire or explosion, structural failure, and environmental accident (spill or release). In the event of any emergency associated with the site work, the removal contractor shall without delay: take diligent action to remove or otherwise minimize the cause of the emergency; treat injured persons; alert the Volpe Center and A&E H&S; and institute whatever measures might be necessary to prevent any repetition of the conditions or actions leading to, or resulting in, the emergency.

1.08 PERSONAL SAFETY AND RELATED EQUIPMENT

A. Provide all onsite personnel with appropriate PPE in accordance with the CSHASP, SSHASP, and applicable regulations. Ensure that all safety equipment and protective clothing is kept clean and well maintained or disposed of as spent contaminated waste.

B. Programs for respiratory protection shall conform to OSHA 1910.134, and hearing protection shall conform to 29 CFR 1910.95.

C. The removal contractor shall provide barricades and warning measures around openings, pits, crawl spaces, excavations, and other areas to ensure personnel protection during the work.

1.09 TRAFFIC CONTROL

A. The removal contractor shall be responsible for controlling vehicular traffic on and adjacent to the site as necessary, in order to assure safe and efficient operations. All signs, flagmen, and related traffic control items shall be in accordance with State of Montana DOT requirements.

1.10 ROAD MAINTENANCE

A. All roadways, haul roads and work areas shall be maintained in good condition throughout the progress of the work.

B. All roadways, driveways, parking areas, or sidewalks damaged or disturbed by the removal contractor's operations shall be repaired, replaced, or restored by the removal contractor to a condition similar or equal to that existing before the damage was done at no additional cost to the government.

1.11 POSTED REGULATIONS

A. The removal contractor shall develop, as required by his SSHASP, a series of posted regulations which shall be reviewed by the Volpe Center. These regulations shall address the onsite protocol regarding use of personal protective equipment, personal hygiene, and provisions regarding smoking and eating.

B. These protocols shall be posted at various prominent locations on site and shall be reviewed with all removal contractors' personnel.

1.12 LABORATORY SERVICES

A. The A&E shall provide and coordinate the services of a qualified independent testing laboratory, approved by the Volpe Center, to perform any services and analyses necessary for the completion of the work.

B. Submit for review and approval, a detailed sampling and laboratory protocol procedure.

C. Qualifications of Laboratory

1. The laboratory shall meet the *Recommended Requirements for Independent Laboratory Qualification*, published by the American Council for Independent Laboratories.

2. The laboratory shall use U.S. Environmental Protection Agency- and American Society for Testing Materials (ASTM)-approved methods and procedures.

3. The laboratory shall be an independent contractor.

D. The A&E shall permit the Volpe Center to perform quality control verification of sampling and analytical work. The A&E shall cooperate with the Volpe Center in obtaining samples for split analysis and shall permit the Volpe Center access to the analytical laboratory.

E. The A&E shall furnish the Volpe Center a copy of all analytical results of tests performed during the course of project work.

1.13 DAILY CLOSEOUT

A. The removal contractor's senior site representative shall attend a daily meeting with the Volpe Center. A regular time for the daily meeting shall be determined by the Volpe Center at the commencement of work.

B. The agenda of the weekly meeting will include, but not be limited to progress, regulatory compliance, health and safety, schedule, problem identification, and other issues as determined by the Volpe Center. The removal contractor shall provide a presentation of project status in accordance with the agenda determined by the Volpe Center.

1.14 LINES AND GRADES

A. The removal contractor shall be responsible for establishing lines and grades required to perform the work. The removal contractor shall cooperate with the Volpe Center, who may periodically review removal contractor compliance through the government's surveying subcontractor.

B. The removal contractor shall be responsible for performing day-to-day grade checks during placement and grading of common fill, topsoil for sodded and seeded areas, and structural fill for roadways and other locations on the property.

END OF SECTION

SECTION 2

SPECIAL PROJECT PROCEDURES

1.01 RELOCATIONS

A. The removal contractor shall be responsible for the relocation of any facilities required to perform the cleanup work.

1.02 OBSTRUCTIONS

A. The attention of the removal contractor is drawn to the fact that during excavation at the site, the possibility exists of the removal contractor encountering various water, electrical, or other lines not shown on the site-specific work plans. Exercise extreme care before and during excavation to locate and flag these lines so as to avoid damage to the existing lines. Should damage occur to an existing line, the removal contractor shall repair the line.

B. It is the responsibility of the removal contractor to ensure that all utility poles or other structures, the stability of which may be endangered by the close proximity of operating equipment, are fully protected.

1.03 ONSITE STORAGE

A. Materials and equipment for use in removal and restoration work shall be stored in appropriate facilities and in an appropriate manner such that they remain secure and in a condition suitable for the intended use.

1.04 EXISTING UTILITY PROTECTION

A. Approximate locations of known existing utilities are shown in the site-specific work plans for properties for which a survey was performed. Locate and protect all utilities, in work areas. The removal contractor shall excavate test pits, coordinated through the Volpe Center, as needed for utility location.

B. The removal contractor shall contact utility companies and U-DIG at 406-755-8344 at least 48 hours before starting construction so utility company personnel can locate their facilities.

1.05 MAINTENANCE OF EXISTING UTILITY SERVICE AND EXISTING FACILITIES OPERATION

A. The removal contractor's schedule and work shall, at all times, be subject to alteration, revision, or halted if necessary for public health and safety considerations.

B. In no case will the removal contractor be permitted to interfere with any existing utility services, unless prior approval has been obtained from the Volpe Center. Work shall not begin until all materials, supplies, equipment, tools, and incidentals and engineering controls are on the job site and in place as necessary to complete the work.

C. The removal contractor shall work 24 hours per day in all cases where interferences with existing utility service may result in interruptions, health hazards, or serious inconveniences to persons served by the utilities.

1.06 SECURITY

A. The removal contractor shall provide security for the residential properties undergoing removal activities under this task order during work hours. The removal contractor shall at all times be responsible for the security of its vehicles, equipment, tools, temporary facilities, decontamination trailers, water storage tanks, portable toilets, and materials used in the removal/restoration activities.

B. The government will provide security of the residential dwellings after work hours. Government provided, after hours security may range from a roving security guard assigned to several residential properties within close proximity to each other, or a single security guard assigned to a single residential property as determined by the government.

1.07 DAMAGE ON ACCOUNT OF HIGH WATER

A. Removal contractor shall be responsible for all damage done to their work by heavy rains or floods and they shall take all reasonable precautions to provide against damages by building such temporary dikes, channels, or shoring to carry off storm water as the nature of the work may require.

1.08 EMERGENCY PHONE NUMBERS AND ACCIDENT REPORTS

A. Emergency phone numbers (fire, medical, police) shall be posted at the removal contractor's phone and its location known to all working at the site.

B. Accidents shall be reported immediately to A&E H&S by messenger or phone.

C. All accidents shall be documented and a fully detailed written report submitted to A&E H&S within 48 hours after each accident. Accident investigations shall be conducted by the removal contractor to identify the cause and ensure that the incident does not recur.

D. The emergency poster shall be posted onsite in a highly visible location for the duration of removal contractor site activities, including restoration.

1.09 WEATHER PROTECTION

A. In the event of inclement weather, the removal contractor shall protect the work and materials from damage or injury from the weather. If, in the opinion of the Volpe Center, any portion of the work or materials has been damaged by reason of failure on the part of the removal contractor to so protect the work, such work and materials shall be removed and replaced at the removal contractor's expense with new materials and work to the satisfaction of the Volpe Center. This will include freezing conditions late in the construction season.

END OF SECTION

SECTION 3

ENVIRONMENTAL PROTECTION PROCEDURES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, and equipment, and perform all work required for the prevention of environmental pollution in conformance with applicable state and federal laws and regulations during and as the result of construction operations. For the purpose of this Section, environmental pollution is defined as the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to man; or degrade the utility of the environment for aesthetic and/or recreational purposes.

B. The control of environmental pollution requires consideration of air, water, and land, and involves management of noise and solid waste, as well as other pollutants.

C. Schedule and conduct all work in a manner that will prevent erosion of soils in the area of the work. Provide erosion control measures such as diversion channels, sedimentation or filtration systems, berms, staked hay bales, seeding, mulching or other special surface treatments as are required to prevent silting and muddying of on-site drainage channels or streams, etc. All erosion control measures shall be in place in an area prior to any construction activity in that area.

D. These specifications are intended to ensure that construction is achieved with a minimum of disturbance to the existing ecological balance between a water resource and its surroundings. These are general guidelines. It is the removal contractor's responsibility to determine the specific construction techniques to meet these guidelines and maintain all such erosion control measures throughout the performance of this work.

1.02 APPLICABLE REGULATIONS

A. Comply with all applicable federal, state, and local laws and regulations concerning environmental pollution control and abatement.

1.03 NOTIFICATIONS

A. The Volpe Center will notify the removal contractor in writing of any noncompliance with the foregoing provisions or of any environmentally objectionable acts and corrective action to be taken. State or local agencies responsible for verification of certain aspects of the environmental protection requirements may notify the removal contractor in writing directly, or through the EPA or the government, of any noncompliance with state or local requirements. The removal contractor shall, after receipt of such notice from the EPA or government or from the regulatory agency, immediately take corrective action. Such notice, when delivered to the removal contractor or his/her authorized representative at the site of the work, shall be deemed sufficient for the purpose. If the removal contractor fails or refuses to comply promptly, the Volpe Center may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made the subject of a claim for extension of time or for excess costs or damages by the removal contractor unless it is later determined that the removal contractor was in compliance.

1.04 IMPLEMENTATION

A. Prior to commencement of the work, the removal contractor shall meet with the Volpe Center to develop mutual understandings relative to compliance with this provision and administration of the environmental pollution control program as specified in this and other sections.

PART 2 EXECUTION

2.01 EROSION CONTROL

A. The removal contractor shall provide positive means of erosion control such as shallow ditches and construction filter fabric to carry off surface water. Erosion control measures, such as siltation basins, hay check dams, mulching, jute netting, and other equivalent techniques, shall be as specified in the site-specific work plans.

2.02 PROTECTION OF STREAMS

A. Care shall be taken to prevent, or reduce to a minimum, any damage to any onsite drainage channel or stream from pollution by debris, sediment, or other material, or from the manipulation of equipment and/or materials in or near such channels or streams.

B. All preventative measures shall be taken to avoid spillage of petroleum products and other pollutants. In the event of any spillage, prompt remedial action shall be taken.

C. The removal contractor shall ensure that a hydrocarbon spill kit is onsite and available during all removal contractor site activities, including restoration.

2.03 PROTECTION OF LAND RESOURCES

A. Land resources within the project boundaries and outside the limits of permanent work shall be restored to a condition, after completion of construction, that will appear to be natural and not detract from the appearance of the property. Confine all removal and restoration activities to areas shown on the site-specific work plans.

B. The removal contractor shall remove all signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, stockpiles of excess waste materials, or any other vestiges of construction.

2.04 PROTECTION OF AIR QUALITY

A. Burning - The use of burning at the project site for the disposal of refuse and debris will not be permitted.

B. Dust Control - The removal contractor will be required to keep all work sites free from visible dust emissions during all site activities, including restoration.

C. An approved method of stabilization consisting of water sprinkling or other similar methods will be permitted to control dust. The use of petroleum products is prohibited, unless approved by the Volpe Center. The use of chlorides may be permitted with approval from the Volpe Center. The removal contractor shall have water trucks or other means of dust control available on site at all times.

D. Sprinkling, to be approved, must be repeated at such intervals as to prevent visible dust emissions during all site activities, including restoration, and the removal contractor must have sufficient equipment and competent staff on the job to accomplish this. Dust control shall be performed as the work proceeds so that a dust nuisance or hazard does not occur. Polyethylene sheeting may be used as an alternative to sprinkling subject to the approval by A&E H&S.

2.05 MAINTENANCE OF POLLUTION CONTROL FACILITIES DURING CONSTRUCTION

A. During the life of this contract, the removal contractor shall maintain all facilities constructed for pollution control as long as the operations creating the particular pollutant are being carried out or until the material concerned has become stabilized to the extent that pollution is no longer being created.

2.06 NOISE CONTROL

A. The removal contractor shall make every effort to minimize noises caused by his/her operations. Equipment shall be equipped with silencers or mufflers designed to operate with the least possible noise in compliance with state and federal regulations.

2.07 WORK HOURS

A. Cleanup work at residential, commercial, public, and other properties shall normally be performed between 7:30 a.m. and 7:00 p.m. Any variations in work hours shall be approved in advance by the Volpe Center.

END OF SECTION

SECTION 4

TEMPORARY FACILITIES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment, and incidentals required to provide the following facilities.

1. Personnel Decontamination Facilities
2. Temporary Electric Power and Potable Water
3. Portable Toilets
4. Security Fence
5. Construction Equipment Storage Area
6. Hazardous Materials Storage Area
7. Equipment Decontamination Facilities
8. Temporary enclosures necessary for contamination removal
9. Local business office and equipment and materials storage area

B. The removal contractor is expressly prohibited from using permanent or semi-permanent office trailers at a cleanup property. It is the removal contractor's responsibility to purchase, rent or lease necessary local office space or office trailers with telephone, water, heat, electricity and office equipment to perform the work of the contract.

PART 2 PRODUCTS

2.01 PERSONNEL DECONTAMINATION FACILITIES

A. Personal decontamination facilities containing a clean room, shower room and equipment room (dirty room) shall be provided and equipped with: lockers for all personnel; potable hot and cold water; eyewash stations; and showers. It shall be a self contained portable box trailer or equivalent equipped with HEPA filtration. PPE storage shall be provided.

2.02 PORTABLE TOILETS

A. Portable toilets for male and female workers and agency personnel shall be provided and staged in the Support Zone and workers must exit through the personnel decontamination facility in order to access these facilities. The removal contractor shall ensure that toilets are not used by personnel who have not undergone the decontamination process. The number of toilet seats and urinals shall be in accordance with the requirements of 20 CFR 1910.20(n)(3)(I), however, there shall be at least one portable toilet at each residential removal(s) location. Portable toilets shall be emptied and cleaned, and liquids, disinfectants, paper, etc. replaced or resupplied every other day during the removal and restoration activities.

PART 3 EXECUTION

3.01 TEMPORARY ELECTRIC POWER AND WATER

A. Removal contractor shall provide temporary electric power and potable water for use in performing this work. Potable water to be used for dust control, personnel decontamination, and other uses, shall be obtained from offsite sources approved by A&E H&S. Temporary water lines shall be provided by the removal contractor, as needed. Refer to the CSHASP for water disinfection requirements.

3.02 HAZARDOUS MATERIALS STORAGE

A. Hazardous materials such as fuel, lubricating oils, and other regulated materials used by the removal contractor for work at a residential removal location shall be stored at the removal contractor's main storage facility. These materials shall not be stored at the residential removal locations.

END OF SECTION

SECTION 5

STORMWATER, SEDIMENTATION, AND EROSION CONTROL

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment, and incidentals necessary to construct and maintain all stormwater controls as specified and required in areas of contaminated soil excavation, removal and other earthwork. Stormwater management consists of controlling stormwater, under two general conditions within the project area. The two general conditions are:

1. Direct uncontaminated run-on (from offsite) away from areas of the project that could cause contamination of the stormwater.

2. Direct potentially contaminated runoff to onsite collection systems.

B. The control of potentially contaminated site runoff is the responsibility of the removal contractor. This storm water management work shall include controlling storm water within the excavation areas shown on the drawings to prevent offsite transport of contaminated storm water. The facilities to manage these storm waters must be capable of collecting, directing and infiltrating 100 percent of the runoff from contaminated areas produced by up to and including 1 1/2 inch of rainfall in 24 hours.

C. The removal contractor shall provide equipment (e.g., pumps, piping, earth working equipment) and personnel to control storm water events. The removal contractor shall be prepared to control flows in excess of the design flows.

D. The removal contractor shall perform all installation, maintenance, removal and area cleanup related to stormwater, sedimentation and erosion control work as specified herein. The work shall include, but not necessarily limited to; installation of temporary access ways and staging areas, silt fences, sediment removal and disposal, device maintenance, removal of temporary devices, temporary mulching, and final cleanup.

E. Silt fences and hay bales shall be installed around excavation areas, surface waters and other locations to prevent runoff into and out of excavation areas. Erosion controls shall be in accordance with the Montana DEQ's *Montana Sediment and Erosion Control Manual* prepared by Roxanne Lincoln, CPSS, MPDES Stormwater Program, Revised May 1996.

F. Erosion control associated with contaminated soil removal and backfilling of the site shall be the responsibility of the removal contractor.

G. Erosion control associated with revegetation of the site shall be the responsibility of the government's landscaping contractor.

1.02 REFERENCES

A. State of Montana Surface Water Quality Standard Stormwater Regulations

1.03 SUBMITTALS

A. Submit to the Volpe Center, technical product literature for all commercial products to be used for stormwater, sedimentation and erosion control in conjunction with the Stormwater, Sedimentation and Erosion Control Plan.

B. The removal contractor shall include in the Stormwater, Sedimentation and Erosion Control Plan stormwater control procedures that address the following items prior to beginning any activities that involve contaminated materials.

1. Controls to prevent stormwater from running off or running onto the property.

2. Control to prevent runoff from entering or accumulating in excavations.

1.04 QUALITY ASSURANCE

A. The removal contractor will be responsible for the timely installation and maintenance of all sedimentation control devices necessary to prevent the movement of sediment from the construction site to offsite areas or into the creek and river system via surface runoff. Measures necessary to prevent the movement of sediment offsite shall be installed, maintained, removed, and cleaned up at the expense of the removal contractor. No additional charges to the government will be considered.

PART 2 PRODUCTS

2.01 MATERIALS

A. Crushed gravel for sediment filtration devices, access ways and staging areas shall conform to applicable requirements included in the *Montana Sediment and Erosion Control Manual*, revised May 1996.

B. Silt Fence

1. Silt fence shall consist of hay bales and polypropylene fabric.

2. Hay bales shall be free from weeds banned in the State of Montana.

3. Silt fence fabric shall be a woven, polypropylene, ultraviolet resistant material such as Mirafi 100X as manufactured by Mirafi, Inc., Charlotte, NC or equal.

4. Prefabricated commercial silt fence may be substituted for built-in-field fence. Prefabricated silt fence shall be "Envirofence" as manufactured by Mirafi Inc., Charlotte, NC or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Construct and maintain all berms and drainage ditches to intercept and manage stormwater as specified herein.

1. Divert runoff from running off or onto the property. Isolate and collect runoff from contaminated areas and convey it to collection facilities.

2. Divert runoff from entering into excavations. Collect runoff from excavation areas and infiltrate within the excavated areas or convey to collection facilities approved by A&E H&S.

3.02 EXCAVATION AREAS

A. Clean surface runoff flowing toward excavation areas shall be collected in shallow ditches and diverted around the perimeter of the excavation.

B. Drainage operations shall be conducted in a manner that does not cause loss of ground or disturbance to the buried pipe bedding or soil that supports overlying or adjacent structures.

3.03 CONTAMINATED MATERIAL HANDLING, STORAGE, AND TREATMENT AREAS

A. Stormwater Removal

Remove all accumulated stormwater as necessary to maintain safe working conditions.

B. Conveyance to Infiltration Depressions

Construct and maintain berms and drainage ditches for conveying runoff from the excavation, contaminated material handling, and storage areas. Provide and maintain sufficient conveyance capacity to accommodate peak flows from runoff areas to collection facilities.

C. Temporary Stormwater Storage

1. Construct and maintain collection facilities for temporary storing of runoff from contaminated areas. Provide and maintain sufficient storage capacity to store the design storm assuming 100 percent runoff. Do not divert runoff from material handling, storage, or treatment areas to the excavation area for storage.

D. Disposal of Stored Water

1. All stormwater collected from excavation areas and other contaminated areas of the property shall be disposed at the Class IV Asbestos Landfill or as directed by A&E H&S.

3.04 UNCONTAMINATED AREAS

Discharge stormwater from uncontaminated areas without treatment except as required by regulations and codes for sediment control. Employ best management practices (BMPs) as necessary for sediment control.

3.05 SILT FENCE INSTALLATION

A. Silt fences shall be positioned as necessary to prevent offsite movement of sediment produced by contaminated soil removal and restoration activities as directed by the A&E.

B. Dig trench approximately 4-inches deep along proposed fence lines.

C. Install pre-fabricated silt fence according to manufacturer's instructions.

3.06 MAINTENANCE AND INSPECTIONS

A. Inspections

1. Make a visual inspection of all stormwater, sedimentation and erosion control devices once per week and promptly after every rainstorm. If such inspection reveals that additional measures are needed to prevent movement of sediment to offsite areas or into the vent trench, promptly install additional devices as needed. Sediment controls in need of maintenance shall be repaired promptly.

B. Device Maintenance

1. Silt Fences

a. Remove accumulated sediment once it builds up to one-half of the height of the fabric.
b. Replace damaged fabric, or patch with a 2-ft minimum overlap.
c. Make other repairs as necessary to ensure that the fence is filtering all runoff directed to the fence.

3.07 REMOVAL AND FINAL CLEANUP

A. Once the property has been backfilled and the site has been fully stabilized against erosion and all other excavation and backfilling work completed, the removal contractor shall remove sediment control devices and all accumulated silt. Dispose of silt and waste materials at the mine site repository or asbestos landfill as ACM as directed by A&E H&S.

END OF SECTION

SECTION 6

ASPHALT PAVING AND SURFACING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, material, equipment testing, and incidentals required to repair all pavement disturbed by the removal contractor's operations.

B. It is the government's intention to restore streets, driveways, parking areas or sidewalk pavements removed, damaged or disturbed by the removal contractor's operations to a condition similar to that which existed prior to contaminated soil removals. Minimum replacement pavement requirements are specified herein.

1.02 SUBMITTALS

A. Submit to the Volpe Center reports showing proposed mix design and estimated Rice's density of rolled, compacted core samples for all bituminous asphalt paving materials and courses to be used on the project, along with evidence that the asphalt tack coat and other materials meet the requirements of Montana Public Works Standard Specification Section 02510.

B. Submit to the government representative a sieve analysis of recycled base material if proposed for use in this project.

1.03 REFERENCE STANDARD

A. All asphalt pavement materials and construction shall be in accordance with Montana Public Works Standard Specification Section 02510, titled Asphalt Concrete Pavement, including all addenda, except as noted and superceded by this specification.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid request shall apply.

PART 2 PRODUCTS

2.01 PAVEMENT MATERIALS

A. Bituminous asphalt concrete paving shall be as specified in Section 02510 of the above reference standard and herein:

1. Structural fill for use as sub-base for asphalt driveways and other paved areas shall consist of an angular, hard, durable, processed, crushed gravel conforming to the requirements of the State of Montana Department of Transportation standard 701.02.5 Crushed Base Course Type "B", Grade 2.

2. Structural fill shall have no particles larger than 1½ inches in largest dimension and conform to the following gradation:

Sieve Size	Percent Finer by Weight
1-1/2 inches	100
No. 4	25 to 55
No. 200	0 to 8

3. Binder and surface course pavements shall be thoroughly compacted by vibratory rolling with a powered steel wheeled roller. At the removal contractor's risk, a five (5) ton steel wheeled static roller may be substituted as long as the compacted thickness and compaction of 95 percent as determined by Rice's density lab testing is achieved.

4. Edges of asphalt paved areas inaccessible to the wheeled roller shall be compacted with a walk-behind vibratory plate compactor.

B. The sprinkling of water for dust control shall be provided by the removal contractor for dust suppression throughout the performance of the work. Chemical dust suppression products shall not be permitted unless approved in advance by the government representative. Removal contractor shall provide potable water for dust control.

PART 3 EXECUTION

3.01 SITE PREPARATION

A. Proof compact the exposed subgrade below areas of structural fill by at least 4 passes of a compactor prior to placing structural fill. Remove any soft areas and replace with structural fill.

B. Structural fill shall be placed in layers having a maximum thickness of 8 inches, loose measure, and compacted to at least 95 percent of the maximum dry density as determined by laboratory test ASTM D1557.

C. Structural fill shall extend to at least 2 feet beyond the limits of paving.

3.02 PAVING - GENERAL

A. Bituminous asphalt concrete pavement shall be installed in accordance with Section 02510 of the above referenced standards.

B. Bituminous mixtures shall be placed on the approved base only when the course is sufficiently dry and weather conditions are suitable.

C. Each course shall be spread and finished as required in the referenced standard.

D. The pavement course shall be placed and compacted by steel-wheeled rollers of sufficient weight to thoroughly compact the asphalt pavement as specified above.

E. Maintain pavement during the guarantee period of 1 year and promptly refill and repave areas which have settled or are otherwise unsatisfactory for use at no additional cost to the government.

F. All pavement thicknesses referred to are compacted thicknesses. Place sufficient mix to ensure that the specified thickness of pavement is achieved wherever called for.

G. When required, remove existing pavement by saw, pneumatic hammer or wheel, cutting edges of trenches to be repaved.

H. Hose clean all road surfaces after backfilling and before any surfacing, but in no case will pavement be placed until the gravel base is dry and compacted to at least 95 percent maximum density at optimum moisture content as specified. Removal contractor shall provide compaction test results to the government.

I. Top elevation of all subsurface utility castings including frames, grates and utility boxes shall be set at finish grade. At no time shall castings be allowed to protrude above the finish grade of pavements or surrounding finish grades.

J. When the air temperature falls below 50 degrees Farenheit (F), extra precautions shall be taken in drying the aggregates, controlling the temperatures of the materials and placing and compacting the mixtures.

K. No mixtures shall be placed when the air temperature is below 40 degrees F, or when the material on which the mixtures are to be placed contains frost.

L. No vehicular use or loads shall be permitted on the newly completed pavement until adequate stability has been attained and the material has cooled overnight to prevent distortion or loss of fines. If the climatic or other conditions warrant it, the period of time before opening to use may be extended at the discretion of the government.

M. All pavements shall be laid over a prepared subbase, thoroughly compacted as specified.

N. Where new asphalt pavement meets existing concrete sidewalks, aprons, ramps, or access roads, create straight, clean and smooth transitions between surfaces by saw cutting and patching where necessary and matching finish grades.

O. Finish grade of all pavements shall have positive drainage. Ponds, puddles, depressed areas or grades creating "bird baths" deeper than 1/8-inch will not be accepted, and such pavements shall be removed and reinstalled at the expense of the removal contractor.

P. Finish all edges with a neat, continuous tamped edge.

3.03 PAVEMENT SETTLEMENT

A. If points of settlement or holes appear in the pavement, the removal contractor shall repair at no additional cost to the government.

3.04 GUARANTEE/WARRANTY

A. All pavement materials placed shall be maintained over the winter and for 1 year following date of acceptance by the government. During this period, all areas that have settled or are unsatisfactory for use shall be refilled and replaced at the direction of the government.

B. All pavements, joint and filler, and pavement sealer shall be guaranteed against defects in workmanship and quality for a period of 1 year after final acceptance. Removal contractor shall repair at no cost to the government.

3.05 PAVEMENT MARKINGS

A. Reline all streets and parking areas with pavement markings equal in type and location to those existing prior to paving.

END OF SECTION

SECTION 7

NON-REINFORCED CONCRETE WALKWAYS AND DRIVEWAYS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment, testing and incidentals required and install concrete walkways and driveways in the locations identified in the site-specific work plans and as specified herein.

B. It is the government's intention to restore/replace residential concrete walkways and driveways damaged or removed during contaminated soil removal activities to a condition similar to that which existed prior to initiation of exterior removal activities.

C. Minimum requirements for non-reinforced residential concrete walkways and driveways are specified herein. The Concrete and Reinforcing Steel Section of these Construction Specifications provides requirements for replacing reinforced concrete sidewalks and other reinforced concrete items at residential, public, commercial and industrial properties.

1.02 REFERENCE STANDARDS

A. ASTM

1. ASTM D1752 – Standard Specification for Premolded Joint Filler (Self Expanding Cork)

B. American Association of State Highway and Transportation Officials (AASHTO)

1. AASHTO M213 - Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete shall be as specified in the Concrete and Reinforcing Steel Section.

B. Premolded joint filler shall be self expanding cork conforming to ASTM D1752, Type III, by A.C. Horn, Inc.; Tamms Industries of Kirkland, IL; W.R. Meadows, Hampshire, IL; or equal.

PART 3 EXECUTION

3.01 SITE PREPARATION

A. Structural fill for use as sub-base for concrete driveways shall consist of an angular, hard, durable, processed, crushed gravel conforming to the requirements of the State of Montana Department of Transportation standard 701.02.5 Crushed Base Course Type "B," Grade 2.

B. Structural fill shall have no particles larger than 1½ inches in largest dimension and conform to the following gradation:

Sieve Size	Percent Finer by Weight
1½ inches	100
No. 4	25 to 55
No. 200	0 to 8

C. Proof compact the exposed subgrade below areas of structural fill by at least 4 passes of a compactor prior to placing structural fill. Remove any soft areas and replace with structural fill.

D. Structural fill shall be placed in layers having a maximum thickness of 8 inches, loose measure, and compacted to at least 95 percent of the maximum dry density as determined by laboratory test ASTM D1557.

3.02 INSTALLATION

A. The subgrade for walkways shall be shaped parallel to the proposed surface of the walkways and thoroughly compacted. All depressions occurring shall be filled and again compacted until the surface is smooth and hard.

B. After the subgrade has been prepared, a structural fill base course shall be placed. After being thoroughly compacted, the base course shall be at least 8-inches in thickness and parallel to the proposed surface of the walkway.

C. Forms

1. Side and transverse forms shall be smooth, free from warp, of sufficient strength to resist springing out of shape, of a depth to conform to the thickness of the walkway and of a type satisfactory to the Engineer.

2. All mortar or dirt shall be completely removed from forms that have been previously used. The forms shall be well staked and thoroughly braced and set to the established lines with their upper edge conforming to the grade of the finished walk which shall have sufficient pitch to provide for surface drainage, but not to exceed 1/4-inch/foot.

3. All forms shall be oiled as specified in the Concrete and Reinforcing Steel Section before placing concrete.

D. Placing and Finishing Concrete

1. Concrete walkways shall be placed in alternate slabs not exceeding 30 feet in length, except as otherwise ordered. The slabs shall be separated by transverse, preformed expansion joint filler.

2. Tooled joints shall be spaced at a 5 foot maximum.

3. Preformed expansion joint filler shall be placed adjacent to structures as directed.

4. Concrete shall be placed in such quantity that, after being thoroughly consolidated in place, it shall be 4-inches in depth. Finishing operations shall be delayed until all bled water and water sheen has left the surface and concrete has started to stiffen. After water sheen has disappeared, edging operations shall be completed. After edging and jointing operations, the surface shall be floated with an aluminum or magnesium float. Immediately following floating, the surface shall be steel troweled. Tooled joints and edges shall be rerun before and after troweling to maintain uniformity. Finish with broom at right angles to alignment of walk, then round all edges with 1/4-inch radius after brooming.

5. Sidewalk Finish: Walks adjacent to structures shall slope down ¼ inch/foot away from structures, unless otherwise shown. The surface shall be struck off by means of a strike board and floated with a wood or cork float to a true plane, then flat steel troweled before brooming. The surface shall be broomed at right angles to the direction of traffic. Sidewalk surfaces shall be laid out as agreed to by the government and property owner.

6. Driveways, walkways and other concrete slabs shall be constructed to slope away from structures to the grades which existed prior to exterior removal activities or as agreed upon between the government and property owner. All slabs shall receive a broom finish.

7. When completed, the walkways shall be kept moist and protected from traffic and weather for at least 3 days.

END OF SECTION

SECTION 8

CORRUGATED METAL PIPE

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment and incidentals required to furnish and install any corrugated metal pipe damaged during removal activities.

1.02 SUBMITTALS

A. Submit the name of the pipe supplier and a list of materials to be furnished. The submittal shall include the following:

1. Shop drawings showing layout, joint, method of manufacture and installation of pipe and a schedule of pipe lengths.

2. Prior to shipment of pipe, submit certified test reports that the pipe for this project was manufactured and tested in accordance with the ASTM and American Water Works Association (AWWA) standards specified herein.

1.03 REFERENCE STANDARDS

A. ASTM

1. ASTM A444 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process for Storm Sewer and Drainage Pipe.

B. AWWA

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. Inspection of the pipe shall be made by the A&E at the point of fabrication or after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specified requirements, even though pipes may have been accepted as satisfactory at the place of fabrication. Pipe rejected after delivery shall be marked for identification and removed from the site.

PART 2 PRODUCTS

2.01 CORRUGATED METAL PIPE

A. The corrugated metal pipe shall be fabricated from zinc coated steel sheets conforming to ASTM A444. The pipe corrugations shall be 2⅔ inches by ½ inch.

B. Pipe shall be fabricated with helical corrugations and a continuous lock or welded seam. The pipe and joints shall be leakproof and capable of withstanding an H-20 live load.

C. Minimum pipe gauges shall be as follows:

Pipe Diameter (inches)	**Minimum Gauge**
12 to 24	16
30 to 36	14
42 to 48	12

2.02 FITTINGS FOR CORRUGATED METAL PIPE

A. Joints

1. Furnish and install one or two-piece corrugated bands which mesh with the corrugations of the pipe ends. Bands shall be tightened by bolts through steel angles built into bands Jointing bands shall be specifically fabricated for the pipe to be used.

PART 3 EXECUTION

3.01 INSTALLATION

A. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe or fittings and the joint surfaces. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying and no piece shall be installed which is found to be defective.

B. As soon as the excavation is completed to the normal grade of the bottom of the trench, place 6 inches minimum structural fill in the trench. Pipe shall be firmly bedded in this gravel to conform accurately to the lines and grades indicated on the site-specific work plans. Blocking under the pipe will not be permitted.

C. For helically corrugated pipe, ends shall bolt together. Keep dirt and gravel out of the joint so that corrugations will fit snugly. As the jointing band is tightened tap it with a mallet to take up slack and ensure a tight joint.

D. Holding the pipe section securely in place with jacks or come-along, place structural backfill, bringing it up evenly on both sides of the pipe. Compact the backfill as it is placed. Continue backfilling and compacting until structural fill is at mid-depth of pipe.

E. Carefully regulate the equipment and construction operations such that the loading of the pipe does not exceed the loads for which the pipe is designed and manufactured. Any pipe damaged during construction operations shall promptly and satisfactorily be repaired or replaced at the removal contractor's expense.

END OF SECTION

SECTION 9

LANDSCAPING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Landscaping in areas identified in the site-specific work plans will be performed by the government's landscaping contractor. Should the removal contractor disturb or damage a landscaped area on a property that was not identified as a soil removal area, the removal contractor shall restore the disturbed or damaged landscaped area in accordance with the requirements of this Section at its expense.

B. The government's landscaping contractor will furnish all labor, materials, equipment, tools, sod, seed, plant material, supervision, and incidentals necessary for landscaping of excavation areas and other areas identified in the site-specific work plans and specified herein. The topsoil, provided by the government, will have sufficient organic matter and meet the textural and pH requirements required to support sod or seed growth. The application of pesticides will only be required when directed by the government.

C. The government's landscaping contractor will prepare the final seed bed by tilling, hand raking and other approved methods prior to seeding and/or sodding. The government's landscaping contractor will furnish and install all plant materials and related work, including but not limited to excavation, backfilling, watering, mulching and all incidental work required to complete the landscaping of contaminated soil removal areas and other disturbed areas.

1.02 REFERENCES

A. ARM

1. ARM 4.5.201 - 4.5.204 Noxious Weed Management

B. Agricultural Marketing Service (AMS)

1. AMS-01 (Aug 95) Federal Seed Act Regulations Part 201

C. American Nursery and Landscape Association (ANLA)

1. American National Standards Institute (ANSI)/ANLA Z60.1 (1996) Nursery Stock

D. ANSI

1. ANSI A300 (1995) Tree Care Operations - Trees, Shrubs, and Other Woody Plant Maintenance

E. Camp Dresser & McKee/Montana State University

1. (1998) Best Management Practices for Upland Reclamation Activities, Clark Fork River Basin

F. State of Montana

1. MCA 80-5-134 - Agricultural Seed Requirements

G. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 SUBMITTALS

A. Government approval is required for submittals with an AGA@ designation; submittals having an AFIO@ designation are for information only.

B. Manufacturer's Literature – Manufacturer's literature discussing physical characteristics, application, and installation instructions for equipment and surface erosion control material.

C. Equipment List - A list of proposed pesticide application, seeding, sodding, and mulching equipment to be used in performance of seeding and sodding operation, including descriptive data and calibration tests.

D. Delivery Schedule - A delivery schedule shall be provided at least 10 days prior to the intended date of the first delivery of any materials listed in Part 2 herein.

E. Application of Pesticide - A pesticide treatment plan with proposed sequence of pesticide treatment work shall be submitted prior to application of pesticide. The pesticide trade name, chemical composition, formulation, concentration, application rate of active ingredients, method of application for all materials, and the name and state license number of the state-certified applicator shall be included.

F. Certificates of compliance certifying that materials meet the requirements specified, prior to the delivery of materials. Certified copies of the reports for the following materials shall be included.

G. Seed - Seed origin, classification, botanical name, common name, percent pure live seed, minimum percent germination and hard seed, maximum percent weed seed content, and date tested. The government landscaping contractor shall supply the Volpe Center with all seed bag tags and a certification from the supplier stating that the seed complies with applicable local, state, and federal regulations.

H. Sod - Classification, botanical name, common name, mixture percentage of species, percent purity, quality grade, and field location. The government landscaping contractor shall supply the Volpe Center with a certification from the supplier stating that the sod complies with applicable local, state, and federal regulations.

I. Mulch - Composition and source.

J. Pesticide - EPA registration number and registered uses.

K. Plant Material - Plant material origin, classification, botanical name, common name, and size.

L. Quantity Check - Bag count or bulk weight measurements of material used compared with area covered, to determine the application rate and quantity installed.

M. Equipment Calibration Test Results - Equipment calibration test results including data and calibration records.

1.04 SOURCE INSPECTION

A. The source of seed, sod, and plant materials shall be subject to inspection by the Volpe Center.

1.05 DELIVERY, INSPECTION, STORAGE, AND HANDLING

A. Delivery

1. Sod - Sod shall be protected during delivery to prevent desiccation, internal heat buildup, or contamination.

2. Pesticides - Pesticide material shall be delivered to the site in the original, unopened containers bearing legible labels indicating the EPA registration number and the manufacturer's registered uses.

3. Plant Material Identification and Protection During Delivery - Plant material shall be identified with attached, durable, waterproof labels and weather-resistant ink, stating the correct botanical plant name and size. Plant material shall be protected during delivery to prevent desiccation and damage to the branches, trunk, root system, or earth ball. Branches shall be protected by tying-in. Exposed branches shall be covered during transport.

B. Inspection

1. Seed - Seed shall be inspected upon arrival at the job site for conformity to species and quality. Seed that is wet, moldy, or bears a test date 5 months or older shall be rejected.

2. Sod - Sod shall be inspected upon arrival at the job site for conformity to species. Sod shall be checked for visible broadleaf weeds, and a visible consistency with no obvious patches of foreign grasses that exceed 2 percent of the canopy. Sod that is heating up, dry, moldy, yellow, irregularly shaped, torn, or of uneven thickness shall be rejected.

3. Plant Material - Plant material shall be well shaped and vigorous with a healthy, well-branched root system, free from disease, harmful insects and insect eggs, sunscald injury, disfigurement, or abrasion. Plant material shall be checked for unauthorized substitution and to establish nursery-grown status. Plant material showing desiccation, abrasion, sunscald injury, disfigurement, or unauthorized substitution shall be rejected. The plant material shall exhibit typical form of branch to height ratio, and meet the caliper and height measurements specified herein. Plant material that measures less than specified, or has been poled, topped off, or headed back shall be rejected. Container-grown plant material shall show new fibrous roots and the root mass shall contain its shape when removed from the container. Plant material with broken or cracked earth balls or broken containers shall be rejected. Unacceptable material shall be removed from the job site.

C. Storage

1. Materials shall be stored in designated areas. Seed shall be stored in cool, dry locations away from contaminants.

2. Sod shall be stored in designated areas and kept in a moist condition by watering with a fine mist and covered with moist burlap, straw, or other covering. Covering shall allow air to circulate, preventing internal heat from building up. Sod shall be protected from exposure to wind and direct sunlight until installed.

3. Plant material not installed on the day of arrival at the site shall be stored and protected in designated areas. Plant material shall not be stored longer than 30 calendar days. Plant material shall be protected from direct exposure to wind and sun. Bare-root plant material shall be heeled in. All plant material shall be kept in a moist condition by watering with a fine mist spray until installed.

D. Handling

1. Except for bulk deliveries, materials shall not be dropped or dumped from vehicles. Sod shall not be damaged during handling. Plant material shall not be injured in handling. Cracking or breaking the earth ball of balled and burlapped plant material shall be avoided. Plant material shall not be handled by the trunk or stems.

E. Time Limitation

1. The hydroseeding time limitation for holding seed in the slurry shall be a maximum 24 hours. Time limitation between harvesting and installing sod shall be a maximum 36 hours. Except for container-grown plant material, the time limitation between digging and installing plant material shall be a maximum of 90 calendar days. The time limitation between installing the plant material and placing the mulch shall be a maximum of 24 hours.

PART 2 PRODUCTS

2.01 GENERAL

A. The government landscaping contractor shall provide all materials and equipment in suitable and adequate quantity and quality as required to accomplish the work shown and specified herein.

2.02 SEED

A. Seed Classification - State-certified seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for percentages of mixture, purity, germination, hard seed, weed seed content, and inert material. Labels shall be in conformance with AMS-01 and applicable state seed laws. The following must appear on the label:

1. Lot number or other distinguishing mark.

2. The common name, genus, species (and subspecies, when applicable), including the name of each kind of seed present in excess of 5 percent. When two or more kinds of seed are named on the label, the label shall specify the percentage of each. When only one kind of seed is present in excess of 5 percent and no variety name or type designation is shown, the percentage must apply to seed of the kind named. If the name of the variety is given, the name may be associated with the seed of the kind named. If the name of the variety is given, the name may be associated with the name of the kind. The percentage in this case may be shown as pure seed and must apply only to seed of the variety named.

3. State or County of Origin.

4. The approximate percentage of viable seed, together with the date of the test. When labeling mixtures, the percentage of viability of each kind shall be stated.

5. The approximate percentage by weight of pure seed, meaning the freedom of seed from inert matter and from other seeds.

6. The approximate percentage by weight of sand, dirt, broken seeds, sticks, chaff, and other inert matter.

7. The approximate total percentage by weight of other seeds.

8. The name and approximate number of each kind of species of prohibited and restricted noxious weed seeds occurring per pound of seed.

9. The full name and address of the person, firm, or corporation selling the seed.

B. Seed Species and Mixtures

1. Seed species and mixtures shall be proportioned by weight as shown in Table 1.

Table 1
Revegetation Seed Mixture

Botanical Name	***Common Name***	***Drill Seeding***	***Broadcast Seeding***
		Pounds Pure Live Seed per Acre	
Graminoids			
Festuca ovina, var. *Covar*	Sheep fescue	0.30	0.60
Bromus marginatus, var. *Bromar*	Mountain brome	2.49	4.98
Phleum alpinum	Alpine timothy	0.16	0.32
Secale cereale	Cereal rye	3.00	6
Agrostis scabra	Ticklegrass	0.05	0.10
Agropyron riparium, var. *Sodar*	Streambank wheatgrass	1.74	3.48
Deschampsia caespitosa	Tufted hairgrass	0.10	0.20
Poa cambyi, var. *Cambar*	Canby bluegrass	0.19	0.38
Lupinus perennis	Wild lupine	4.15	8.30
Achillea millefolium	Western yarrow	0.22	0.44
Total		**12.40**	**24.80**

C. Quality

1. Per MCA 80-5-134, seed shall contain no prohibited noxious weed seed. The seed shall contain no restricted noxious weed seed in excess of the maximum numbers per pound as specified by the State of Montana or as specified by the appropriate county Weed Board, whichever is more stringent.

2. The number of seed allowed per pound, for all the noxious weed seeds listed in ARM 4.5.201 through 4.5.204, shall be 0.

3. All seed shall be a standard grade adapted to Montana conditions. Seed that has become wet, moldy, or otherwise damaged shall be rejected.

4. Substitutions - Substitutions will not be allowed without written request and approval from the Volpe Center.

2.03 SOD

A. Sod Classification

1. State-certified or nursery-grown sod shall be provided as classified by applicable state laws. Sod section shall be sized to permit rolling and lifting without breaking.

B. Grass Species

1. Grass species shall be Kentucky Bluegrass (*Poa pratensis*).

C. Quality

1. Sod shall be relatively free of thatch, diseases, nematodes, soil-borne insects, weeds or undesirable plants, stones larger than 1 inch in diameter, woody plant roots, and other materials detrimental to a healthy stand of grass plants. Broadleaf weeds and patches of foreign grasses shall be a maximum 2 percent of the sod section.

D. Thickness

1. Sod shall be machine cut to a minimum 1-3/8 inch thickness. Measurement for thickness shall exclude top growth and thatch.

E. Anchors

1. Sod anchors shall be as recommended by the sod supplier.

F. Substitutions

1. Substitutions will not be allowed without written request and approval from the Volpe Center.

2.04 PLANT MATERIAL

A. Plant Material Classification

1. The plant material shall be nursery-grown stock conforming to ANLA ANSI/ANLA Z60.1 or locally obtained stock and shall be the species specified. Shrub and tree species must be comparable to those species removed during the reclamation; they must be of the same seasonal variety, adapted to the climate and habitat, and be native to the area. Plant material species to be used for reclamation will be specified by the Volpe Center or A&E.

B. Substitutions

1. Substitutions will not be permitted without written request and approval from the Volpe Center.

C. Quality

1. Well-shaped, well-grown, vigorous plant material having healthy and well-branched root systems in accordance with ANLA ANSI/ANLA Z60.1 shall be provided. Plant material shall be provided free from disease, harmful insects and insect eggs, sunscald injury, disfigurement, and abrasion. Plant material shall be free of shock or damage to branches, trunk, or root systems, which may occur from the digging and preparation for shipment, method of shipment, or shipment. Plant quality is determined by the growing conditions, method of shipment to maintain health of the root system, and growth of the trunk and crown as follows.

D. Growing Conditions

1. Plant material shall be native to or well suited to the growing conditions of the project site. Plant material shall be grown under climatic conditions similar to those at the project site.

E. Method of Shipment to Maintain Health of Root System

1. Balled and Burlapped (BB) Plant Material - Ball size and ratio shall be in accordance with ANLA ANSI/ANLA Z60.1. The ball shall be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant. The root ball shall be completely wrapped with burlap or other suitable material and securely laced with biodegradable twine.

2. Balled and Potted (Pot) Plant Material - Ball size and ratio shall be in accordance with ANLA ANSI/ANLA Z60.1. The ball shall be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant. The container shall be sufficiently rigid to hold ball shape and protect root mass during shipping.

3. Container-Grown (C) Plant Material - Container size and ratio shall be in accordance with ANLA ANSI/ANLA Z60.1. Plant material shall be grown in a container over a duration of time for new fibrous roots to have developed and for the root mass to retain its shape and hold together when removed from the container. The container shall be sufficiently rigid to hold ball shape and protect root mass during shipping.

F. Growth of Trunk and Crown

1. Coniferous evergreen plant material shall have the height-to-spread ratio recommended by ANLA ANSI/ANLA Z60.1. Acceptable plant material shall be exceptionally heavy, well shaped, and trimmed to form a symmetrical and tightly knit plant.

G. Plant Material Measurement

1. Plant material measurements shall be in accordance with ANLA ANSI/ANLA Z60.1.

2.05 MULCH

A. Mulch shall be free from weeds, mold, and other deleterious materials. Mulch materials shall be native to the region. Mulch shall be applied at a rate of 2 tons per acre.

B. Straw

1. Straw shall be stalks from oats, wheat, rye, barley, or rice, furnished in air-dry condition, and with a consistency for placing with commercial mulch-blowing equipment.

C. Hydromulch

1. Hydromulch may be applied to the affected areas after those areas have been seeded. Hydromulch shall not be applied simultaneously with hydroseed.

2.06 WATER

A. Water required during seed and sod bed preparation, sodding, seeding, planting, and related landscaping work shall be the responsibility of the government landscaping contractor. Unless the property owner specifically permits use of city water delivered to the property, the government landscaping contractor shall be responsible for providing all water needed for completing the work described in this Section. Water shall not contain elements or compounds toxic to plant life. Watering during establishment period shall be the responsibility of the property owner.

2.07 PESTICIDE

A. Pesticide shall be insecticide, fungicide, nematocide, rodenticide, or miticide. For the purpose of this specification, a soil fumigant shall have the same requirements as a pesticide. The pesticide material shall be EPA registered and approved.

2.08 SURFACE EROSION CONTROL MATERIAL

A. Surface Erosion Control Blanket

1. Blanket shall be machine produced mat of wood excelsior formed from a web of interlocking wood fibers; covered on one side with either knitted straw blanket-like mat construction; covered with biodegradable plastic mesh; or interwoven biodegradable thread, plastic netting, or twisted kraft paper cord netting.

B. Surface Erosion Control Fabric

1. Fabric shall be knitted construction of polypropylene yarn with uniform mesh openings 3/4- to 1-inch square with strips of biodegradable paper. Filler paper strips shall have a minimum life of 6 months.

C. Surface Erosion Control Net

1. Net shall be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately 1-inch square.

D. Erosion Control Material Anchors

1. Erosion control anchors shall be as recommended by the manufacturer.

2.09 PLANT MATERIAL STAKING AND GUYING MATERIALS

A. Wood Staking Material

1. Wood stakes shall be hardwood or fir, rough sawn, free from knots, rot, cross grain, or other defects that would impair their strength.

2. Bracing Stake - Wood-bracing stakes shall be a minimum 2-inch by 2-inch square and a minimum 8 feet long with a point at one end. Stake shall be set without damaging root ball.

3. Wood Ground Stakes - Wood ground stakes shall be a minimum of 2-inch by 2-inch square and a minimum 3 feet long with a point at one end.

B. Metal Staking and Guying Material

1. Metal shall be aluminum or steel consisting of recycled content made for holding plant material in place.

2. Bracing Stakes - Metal bracing stakes shall be a minimum 1-inch diameter and 8 feet long. Stake shall be set without damaging root ball.

3. Metal Ground Stakes - Metal ground stakes shall be a minimum 2-inch diameter and 3 feet long.

4. Earth Anchor - Metal earth anchors shall be a minimum 2-inch diameter and 2 feet long.

5. Guying Material - Metal guying material shall be a minimum 12-gauge wire. Multi-strand cable shall be woven wire. Guying material tensile strength shall conform to the size of tree to be held firmly in place.

6. Turnbuckle - Metal turnbuckles shall be galvanized or cadmium-plated steel and shall be a minimum 3 inches long with closed screw eyes on each end. Screw thread tensile strength shall conform to the size of tree to be held firmly in place.

C. Plastic Staking and Guying Material

1. Plastic shall consist of recycled plastic product made for holding plant material firmly in place. Plastic shall not be used for deadmen.

2. Plastic Bracing Stakes - Plastic bracing stakes shall be a minimum 2-inch diameter and 8 feet long. Stake shall be set without damaging root ball.

3. Plastic Ground Stakes - Plastic ground stakes shall be a minimum 1-inch diameter and 3 feet long.

4. Plastic Guying Material - Plastic guying material shall be designed specifically for the purpose of firmly holding plant material in high wind velocities.

5. Chafing Guard - Plastic chafing guards shall be used to protect tree trunks and branches when metal is used as guying material. The material shall be the same color throughout all work areas. Length shall be a minimum 1.5 times the circumference of the plant trunk at its base.

D. Rubber Guying Material

1. Rubber chafing guards, consisting of recycled material, shall be used to protect tree trunks and branches when metal guying material is applied. The material shall be the same color throughout all work areas. Length shall be a minimum 1.5 times the circumference of the plant trunk at its base.

2.10 FLAG

A. Plastic flag material shall be used on guying material. It shall be a minimum 6-inches long. Tape color shall be consistent and visually complimentary to all work areas.

2.11 TREE ROOT BARRIERS

A. Tree root barriers shall be metal or plastic consisting of recycled content. Barriers shall use vertical stabilizing members to encourage downward tree root growth. Barriers shall limit, by a minimum 90 percent, the occurrence of surface roots. Tree root barriers which are designed to be used as plant pit liners shall be rejected.

2.12 DECORATIVE ROCK

A. Decorative rock shall consist of clean, sound, durable particles of natural gravel, crushed gravel, crushed stone, or slag. The decorative rock shall be asbestos free, typical of that used locally in landscaping applications. Decorative rock shall be free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign materials.

2.13 INERT MEMBRANE

A. Inert membrane shall consist of polyethylene that conforms to ASTM D2103, be 4 mils thick, and be black in color.

2.14 EDGING MATERIAL

A. Metal

1. Metal edging shall be galvanized steel with slots provided for stakes and shall be at least 12-guage, 10-inches wide and supplied in at least 16 foot lengths. Anchoring stakes shall be of similar material and 16- to 18-inches long and tapered.

B. Plastic

1. Plastic edging shall be 4-5/8 inches deep by ¼-inch thick in 15 foot lengths.

PART 3 EXECUTION

3.01 EDGING

A. Edging materials for plant beds shall be in installed in accordance with manufacturer's recommendations. Bed size and shape shall be as indicated on the site-specific work plans.

3.02 DECORATIVE ROCK PLACEMENT

A. Decorative rock shall be placed on inert membrane in locations shown on the site-specific work plans to match the original condition. The decorative rock shall be spread evenly to a depth of 4 inches.

3.03 SEEDING TIME AND CONDITIONS

A. Seeding Time

1. Seeding shall be permitted from April 30 through October 15.

B. Seeding Conditions

1. Sloped backfilled areas finished during the period of April 30 through October 15 shall be covered and permanently seeded within this time period. The government landscaping contractor shall obtain permission from the Volpe Center prior to commencing growth media placement, amendment addition, and seeding. Erosion control methods shall be implemented on slopes and areas finished during the period of October 16 and April 29.

C. Equipment Calibration

1. Calibration tests shall be conducted on the equipment to be used immediately prior to the commencement of seeding operations. These tests shall confirm that the equipment is operating within the manufacturer's specifications and will meet the specified criteria. The equipment shall be calibrated a minimum of once every day during the operation. The calibration test results shall be provided to the Volpe Center within 1 week of testing.

3.04 SEED BED PREPARATION

A. Finished Grade and Growth Media

1. The government landscaping contractor shall verify that finished grades have been completed as indicated on the site-specific work plans or to pre-construction grades on properties where a topographic survey was not performed.

B. Seed Bed Condition

1. It is necessary, insofar as it is practicable and feasible, as determined by the Volpe Center, that the seed bed surface, at the time of seed application, not be excessively wet, snow-covered, or frozen. The seedbed surface shall be reasonably free of large lumps, clods, and impervious crusts of growth media. The seedbed surface, to a depth of approximately 4 inches, shall not be so tightly compacted that seed cannot begin growth. The objective for the seedbed is to create a moderately rough surface.

C. Tillage

1. Soil on slopes up to a maximum 3-horizontal-to-1-vertical shall be tilled to a minimum 4-inch depth. On slopes between 3-horizontal-to-1-vertical and 1-horizontal-to-1 vertical, the soil shall be tilled to a minimum 2-inch depth by scarifying with heavy rakes, or other method. Rototillers shall be used where soil conditions and length of slope permit. On slopes 1-horizontal-to-1 vertical and steeper, no tillage is required. Drainage patterns shall be maintained as indicated on site-specific work plans or as existed prior to initiation of soil excavation. Areas compacted by construction operations shall be tilled to a 6-inch depth with a ripper. Soil used for repair of surface erosion or grade deficiencies shall conform to growth media requirements.

D. Surface Preparation

1. Preparation - The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove debris. The growth media surface shall be filled or smoothed to remove rills, gullies, and depressions.

2. Field Area Debris - Debris and stones over a minimum 3-inches in any dimension shall be removed from the surface.

3. Protection - Areas with the prepared surface shall be protected from compaction or damage by vehicular or pedestrian traffic and surface erosion.

3.05 SEED APPLICATION

A. Prior to seed application, any previously prepared surface compacted or damaged shall be reworked. Seeding operations shall not take place when the wind velocity will prevent uniform seed distribution.

B. Seed Installation

1. The seeding method shall be approved by the Volpe Center. The seeding procedure shall ensure even coverage. Gravity feed applicators, which drop seed directly from a hopper onto the prepared soil, shall not be used because of the difficulty in achieving even coverage, unless otherwise approved by the Volpe Center. Absorbent polymer powder shall be mixed with the dry seed at the rate recommended by the manufacturer.

2. Broadcast Seeding - Seed shall be uniformly broadcast at the rate specified in Table 1 using broadcast seeders. Half the total rate of seed application shall be broadcast in one direction, with the remainder of the seed rate broadcast at 90 degrees from the first direction. Seed shall be covered a maximum 3-inch depth by disk harrow, steel mat drag, cultipacker, or other approved device.

3. Drill Seeding - Seed shall be uniformly drilled to a maximum 2-inch depth and at the rate specified in Table 1 using equipment having drills a maximum 7-inches distance apart. Row markers shall be used with the drill seeder. Half the total rate of seed application shall be drilled in one direction, with the remainder of the seed rate drilled at 90 degrees from the first direction. The drilling equipment shall be maintained with half full seed boxes during the seeding operations.

4. Hydroseeding - Seed shall be added to water and thoroughly mixed to meet the seed mixture specified in Table 1. The time period for the seed to be held in the slurry shall be a maximum 24 hours. Slurry shall be uniformly applied under pressure over the entire area. The hydroseeded area shall not be rolled.

5. Rolling - The entire area shall be firmed with a roller not exceeding 90 pounds per foot roller width. Slopes over a maximum 3-horizontal-to-1-vertical shall not be rolled. Areas seeded with seed drills equipped with rollers shall not be rolled. Hydroseeded areas shall not be rolled.

C. Mulching

1. Straw Mulch - Straw mulch shall be spread uniformly at the rate of 2 tons per acre. Mulch shall be spread by hand, blower-type mulch spreader, or other approved method. Mulching shall be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch shall not be bunched or clumped. Sunlight shall not be completely excluded from penetrating to the ground surface. All areas installed with seed shall be mulched on the same day as the seeding. Mulch shall be anchored immediately following spreading.

2. Mechanical Anchor - Mechanical anchor shall be a V-type-wheel land packer, a scalloped-disk land packer designed to force mulch into the soil surface, or other suitable equipment.

3. Wood Cellulose Fiber, Paper Fiber, and Recycled Paper - Wood cellulose fiber, paper fiber, or recycled paper shall be applied as part of the hydroseeding operation. The mulch shall be mixed and applied in accordance with the manufacturer's recommendations.

D. Watering Seed

1. Residential Area Landscaping – The government landscaping contractor shall begin watering immediately after completing seeding of an area. The government landscaping contractor shall water seeded and landscaped areas for 7 days, the property owner will be responsible for watering the seeded area thereafter.

3.06 SODDING TIME AND CONDITIONS

A. Sodding Time

1. Sodding shall be permitted from April 30 through October 15.

B. Sodding Conditions

1. Sodding operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture or other unsatisfactory conditions prevail, the work shall be stopped when directed by the Volpe Center. When special conditions warrant a variance to the sodding operations, proposed alternate times shall be submitted for approval to the Volpe Center.

C. Equipment Calibration

1. Calibration tests shall be conducted on the equipment to be used immediately prior to the commencement of sodding operations. These tests shall confirm that the equipment is operating within the manufacturer's specifications and will meet the specified criteria. The equipment shall be calibrated a minimum of once every day during the operation. The calibration test results shall be provided to the Volpe Center within 1 week of testing.

3.07 SOD BED PREPARATION

A. Finished Grade and Growth Media

1. The government landscaping contractor shall verify that finished grades have been completed as indicated on the site-specific work plans, and the placing of growth media, smooth grading, and compaction requirements have been completed, prior to the commencement of the sodding operation.

B. Sod Bed Condition

1. It is necessary, insofar as it is practicable and feasible, as determined by the Volpe Center, that the sod bed surface, at the time of sod placement, not be excessively wet, snow-covered, or frozen. The sod bed surface shall be reasonably free of large lumps, clods, and impervious crusts of growth media. The sod bed surface, to a depth of approximately 4-inches, shall not be so tightly compacted that sod cannot continue growth. The objective for the sod bed is to create a moderately rough surface.

C. Tillage

1. Soil on slopes up to a maximum 3-horizontal-to-1-vertical shall be tilled to a minimum 4-inch depth. On slopes between 3-horizontal-to-1-vertical and 1-horizontal-to-1-vertical, the soil shall be tilled to a minimum 2-inch depth by scarifying with heavy rakes or other method. Rototillers shall be used where soil conditions and length of slope permit. On slopes 1-horizontal-to-1-vertical and steeper, no tillage is required. Drainage patterns shall be maintained as indicated on site-specific work plans or as existed prior to initiation of soil excavation. Areas compacted by construction operations shall be tilled to a 6-inch depth with a ripper. Soil used for repair of surface erosion or grade deficiencies shall conform to growth media requirements. The pH adjuster and soil conditioner may be applied during this procedure.

D. Surface Preparation

1. Preparation - The prepared surface shall be a maximum 1-inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove debris. The growth media surface shall be filled or smoothed to remove rills, gullies, and depressions.

2. Field Area Debris - Debris and stones over a minimum 1-inch in any dimension shall be removed from the surface.

3. Protection - Areas with the prepared surface shall be protected from compaction or damage by vehicular or pedestrian traffic and surface erosion.

3.08 SOD INSTALLATION

A. Prior to installing sod, any previously prepared surface compacted or damaged shall be reworked. Areas shall be sodded in the areas shown on the site-specific work plans. Adequate soil moisture shall be ensured prior to sodding by spraying water on the area to be sodded and wetting the soil to a maximum 1-inch depth.

B. Sod Placement

1. Rows of sod sections shall be placed parallel to and tightly against each other. Joints shall be staggered laterally. The sod sections shall not be stretched or overlapped. All joints shall be butted tight. Voids and air drying of roots shall be prevented. Sod sections shall be laid across the slope on long slopes. Sod sections shall be laid at right angles to the flow of water in ditches. Sod sections shall be anchored on slopes steeper than 3-horizontal-to-1-vertical. Anchoring may be required when surface weight or pressure upon placed sod sections is anticipated to cause lateral movement. Sod anchors shall be placed a minimum 2 feet on center with a minimum of two anchors per sod section.

C. Finishing

1. Displacement of the sod shall be prevented by tamping or rolling the sod in place and knitting the sod to the soil. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed, and holes or missing corners shall be patched with sod.

D. Rolling

1. The entire area shall be firmed with a roller not exceeding 90 pounds per foot roller width. Slopes over a maximum 3-horizontal-to-1 vertical shall not be rolled.

E. Watering Sod

1. Watering shall be started immediately after completing each day of sod placement. The government landscaping contractor shall water for 7 days after completion of sod placement. The property owner will be responsible for watering the sodded area thereafter.

3.09 INSTALLING PLANT MATERIAL TIME AND CONDITIONS

A. Deciduous Plant Material Time

1. Deciduous plant material shall be installed at times and under conditions recommended by the nursery.

B. Evergreen Plant Material Time

1. Evergreen plant material shall be installed at times and under conditions recommended by the nursery.

C. Plant Material Conditions

1. Planting operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, frozen ground, or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to the planting operations, proposed planting times shall be submitted for approval.

3.10 SITE PREPARATION FOR PLANT MATERIAL

A. Layout

1. Plant material locations and bed outlines shall be staked on the work area before any planting is made. Plant material locations may be adjusted, if approved by the Volpe Center, to meet field conditions.

B. Protecting Existing Vegetation

1. Existing vegetation shall be protected in accordance with the agreement between the government and property owner. Any damaged vegetation that was supposed to be protected by the removal contractor during excavation and restoration activities shall be replaced by the removal contractor in accordance with this specification at no additional cost to the government.

3.11 EXCAVATION FOR PLANT MATERIAL INSTALLATION

A. Plant pits for balled and burlapped or container-grown plant material shall be dug to a depth equal to the height of the root ball as measured from the base of the ball to the base of the plant trunk. Plant pits for bare-root plant material shall be dug to a depth equal to the height of the root system. Plant pits shall be dug a minimum 50 percent wider than the ball or root system to allow for root expansion. The pit shall be constructed with sides sloping towards the base as a cone, to encourage well-aerated soil to be available to the root system for favorable root growth. Cylindrical pits with vertical sides shall not be used.

3.12 PLANT MATERIAL INSTALLATION

A. Setting Plant Material

1. Plant material shall be set plumb and held in position until sufficient soil has been firmly placed around root system or ball. In relation to the surrounding grade, the plant material shall be set even with the grade at which it was grown.

B. Backfill Procedure

1. Prior to backfilling, all metal, wood, synthetic products, or treated burlap devices shall be removed from the ball or root system avoiding damage to the root system. The backfill procedure shall remove air pockets from around the root system. Additional requirements are as follows:

2. Balled and Burlapped and Balled and Platformed Plant Material - Biodegradable burlap and tying material shall be carefully opened and folded back from the top a minimum 1/3 depth from the top of the root ball. Backfill mixture shall be added to the plant pit in 6-inch layers with each layer tamped.

3. Container-Grown and Balled and Potted Plant Material - The plant material shall be carefully removed from containers that are not biodegradable. Prior to setting the plant in the pit, a maximum 1/4 depth of the root mass, measured from the bottom, shall be spread apart to promote new root growth. For plant material in biodegradable containers, the container shall be split prior to setting the plant with container. Growth media mixture shall be added to the plant pit in 6-inch layers with each layer tamped.

4. Earth Berm - An earth berm, consisting of growth media soil mixture, shall be formed with a minimum 4-inch height around the edge of the plant pit to aid in water retention and to provide soil for settling adjustments.

C. Watering

1. Plant pits shall be watered immediately after backfilling, until completely saturated.

D. Staking and Guying

1. Staking shall be used when trees are unstable or will not remain set due to their size, shape, or exposure to high wind velocity.

E. Pruning

1. Pruning shall be accomplished by trained and experienced personnel. The pruning of trees shall be in accordance with ANSI A300. Only dead or broken material shall be pruned from installed plants. The typical growth habit of individual plant material shall be retained. Clean cuts shall be made flush with the parent trunk. Improper cuts, stubs, dead, and broken branches shall be removed. Cuts at right angles to the line of growth will not be permitted. Trees shall not be poled or the leader removed, nor shall the leader be pruned or topped off.

F. Flags

1. A flag shall be securely fastened to each guy line equidistant between the tree and the stake, deadmen, or earth anchor.

3.13 SURFACE EROSION CONTROL

A. Surface Erosion Control Material

1. Where indicated or as directed, surface erosion control material shall be installed in accordance with manufacturer's instructions. Placement of the material shall be accomplished without damage to installed material or without deviation to finished grade.

B. Temporary Seeding

1. When directed during contract delays affecting the seeding operation or when a quick cover is required to prevent surface erosion, the areas designated shall be seeded in accordance with seed species listed under Paragraph 2.02 herein.

3.14 QUANTITY CHECK

A. For materials provided in bags, the empty bags shall be retained for recording the amount used. For materials provided in bulk, the weight certificates shall be retained as a record of the amount used. The amount of material used shall be compared with the total area covered to determine the rate of application used. Differences between the quantity applied and the quantity specified shall be adjusted as directed.

3.15 APPLICATION OF PESTICIDE

A. When application of a pesticide becomes necessary to remove a pest or disease, a pesticide treatment plan shall be submitted.

B. Application

1. A state-certified applicator shall apply required pesticides in accordance with EPA label restrictions and recommendations. Clothing and personal protective equipment shall be used as specified on the pesticide label. A closed system is recommended as it prevents the pesticide from coming into contact with the applicator or other persons. Water for formulating shall only come from designated locations. Filling hoses shall be fitted with a backflow preventer meeting local plumbing codes or standards. Overflow shall be prevented during the filling operation. Prior to each day of use, the equipment used for applying pesticide shall be inspected for leaks, clogging, wear, or damage. Any repairs are to be performed immediately.

END OF SECTION

SECTION 10

CONCRETE AND REINFORCING STEEL

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment and incidentals required and install all concrete work complete as shown on the site-specific work plans and as specified herein.

B. It is the intention of the government to replace/restore reinforced concrete sidewalks, driveways, walkways and other concrete pavements removed or damaged during contaminated soil removals at residential and other properties to a condition similar to that which existed prior to initiation of exterior removal activities.

1.02 SUBMITTALS

A. Submit shop drawings and product data. Submittals shall include the following:

1. Concrete mix for each formulation of concrete proposed for use including constituent quantities per cubic yard, water-cement ratio, type and manufacturer of cement.

2. Bar placement drawings and bar bending details in conformity with the recommendations of American Concrete Institute (ACI) 315.

3. Technical data on all materials and components.

4. Material Safety Data Sheets (MSDS) for all concrete admixtures and curing agents used in the concrete.

5. A concrete placement plan showing proposed locations of construction joints and a description of the contractor's proposed methods of concrete placement. The plan shall address cold or hot weather concrete procedures as appropriate. The plan shall describe the work force and equipment the contractor plans to use to place, screed and finish each high early strength concrete placement.

B. Test Reports

1. Sieve analysis of fine and coarse aggregates.

2. Concrete mix for each formulation of concrete proposed for use including constituent quantities per cubic yard, water-cement ratio, type and manufacturer of cement, and either a. or b. below.

a. Standard deviation data for each proposed concrete mix based on statistical records.

b. Water-cement ratio curve for each proposed concrete mix based on laboratory tests. Give average cylinder strength test results at 7 days for laboratory concrete mix designs. Provide results of 3, 7 and 28 day tests if available.

C. Certifications

1. Certify admixtures used in the same concrete mix are compatible with each other and the aggregates.

1.03 REFERENCE STANDARDS

A. ASTM

1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. ASTM A185 - Standard Specification for Steel Welded Wire Fabric, Plain for Concrete Reinforcement.
3. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
4. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
5. ASTM C33 - Standard Specification for Concrete Aggregates.
6. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
7. ASTM C143 - Standard Test Method for Slump of Hydraulic Cement Concrete
8. ASTM C150 - Standard Specification for Portland Cement
9. ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
10. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
11. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
12. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.
13. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
14. ASTM D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

B. ACI.

1. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
2. ACI 301 - Standard Specification for Structural Concrete.
3. ACI 305R - Hot Weather Concreting.
4. ACI 306R - Cold Weather Concreting.
5. ACI 315 - Details and Detailing of Concrete Reinforcement.
6. ACI 318 - Building Code Requirements for Structural Concrete.

C. Concrete Reinforcing Steel Institute (CRSI)

1. MSP - Manual of Standard Practice

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. If, during the progress of the work, it is impossible to secure concrete of the required workability and strength with the materials being furnished, the government representative may order such changes in proportions or materials, or both, as may be necessary to secure the desired properties. All changes so ordered shall be made at the removal contractor's expense.

B. Reinforced concrete shall comply with ACI 318.

C. All testing and inspection services required, unless otherwise specified, shall be provided and paid for by the government. Testing necessary to establish the concrete mixes shall be performed by and at the expense of the removal contractor. Methods of testing shall comply with the latest applicable ASTM standards.

1.05 DELIVERY, STORAGE AND HANDLING

A. Reinforcing steel shall be shipped and stored with bars of the same size and shape fastened bundles with durable tags, marked in a legible manner with waterproof markings showing the same designations as shown on the submitted placing drawings. Reinforcing steel shall be free from mill scale, loose rust, dirt, grease, or other foreign matter. Reinforcing steel shall be stored off the ground and protected from moisture, dirt, oil, or other injurious contaminants.

B. Products shall be stored in conformity with the manufacturer's recommendations.

C. Sand, aggregates and cement shall be stored or stockpiled in conformity with the recommendations of ACI 301.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance and manufacturer's service.

C. Materials shall comply with this Section and any applicable state or local requirements.

2.02 MATERIALS

A. Cement shall be domestic portland cement conforming to ASTM C150. The allowable types of cement for each concrete class are shown in Table 1. Air entraining cements shall not be used.

B. Fine aggregate shall be washed inert natural sand conforming to the requirements of ASTM C33.

C. Coarse aggregate shall be a well-graded crushed stone or washed gravel conforming to the requirements of ASTM C33, size 67. Limits of Deleterious Substances and Physical Property Requirements shall be as recommended for severe weathering regions.

D. Water shall be potable, clean and free from injurious amounts of oils, acids, alkalis, organic matter, or other deleterious substances.

E. Concrete admixtures shall be free of chlorides and alkalis (except for those attributable to water). When it is required to use more than one admixture in a concrete mix, the admixtures shall be from the same manufacturer. Admixtures shall be compatible with the concrete mix including other admixtures.

   1. Air entraining admixture shall comply with ASTM C260. Proportioning and mixing shall be in accordance with manufacturer's recommendations.

   2. Water reducing admixture shall comply with ASTM C494, Type A. Proportioning and mixing shall be in accordance with manufacturer's recommendations.

   3. Admixtures causing retarded or accelerated setting of concrete shall not be used without written approval from the government representative. When allowed, the admixtures shall be retarding or accelerating water reducing admixtures.

F. Reinforcing steel bars shall be deformed, intermediate grade, steel conforming to ASTM A615 Grade 60.

G. Welded steel wire fabric shall conform to ASTM A185 and shall be of the size and gauge shown on the detail at the end of this Section.

H. Tie wires for reinforcing steel shall be 16 gauge or heavier, black annealed wire.

I. Precast concrete block bar supports shall conform to CRSI – MSP for Precast Concrete Bar Supports.

J. Premolded joint filler shall be self-expanding cork, conforming to ASTM D1752, Type III. The thickness shall be 3/4-inch unless shown otherwise on the site-specific work plans.

K. Sealant shall be a traffic-grade, polyurethane, elastomeric sealant conforming to ASTM C920 and shall be Sikaflex 2c NS TG by Sika Corporation, Lyndhurst, NJ, or equal.

2.03 MIXES

A. Select proportions of ingredients to meet the design strength and materials limits specified in Table 1 and to produce concrete having proper placability, durability, strength, appearance and other required properties. Proportion ingredients to produce a homogenous mixture which will readily work into corners and angles of forms and around reinforcement without permitting materials to segregate or allowing excessive free water to collect on the surface.

B. The design of each mix shall be based on standard deviation data of prior mixes with essentially the same proportions of the same constituents or, if not available, be developed by independent testing laboratory acceptable to the government representative engaged by and at the expense of the removal contractor. Acceptance of mixes based on standard deviation shall be based on the modification factors for standard deviation tests contained in ACI 318. Acceptance of mixes based on laboratory tests shall be based on strengths greater than the specified design strengths specified in Table 1. The water content of the concrete mixes to be used, as determined from the curve, shall correspond to strengths 16 percent greater than the specified design strength. The resulting mix shall not conflict with the limiting values for maximum water cementitious ratio and net minimum cementitious content specified in Table 1.

C. Compression Tests: Provide testing of the proposed concrete mix or mixes to demonstrate compliance with the compression strength requirements in conformity with the above paragraph.

D. Entrained air, as measured by ASTM C231, shall be as shown in Table 1.

E. Slump of the concrete as measured by ASTM C143, shall be as shown in Table 1.

F. Proportion admixtures according to the manufacturer's recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

Table 1

Class	Design Strength (1)	Cement. ASTM C150	Cement Content (2)	W/C (3)	WR (4)	Slump Range Inches
C	3500	Type II	540	0.45 max.	Yes	3-5

All concrete classes shall have 3.5 to 5 percent air entrainment.

Notes:

(1) Minimum compressive strength at 7 days
(2) Minimum cement content in pounds/cubic yard
(3) W/C is water to cement ratio
(4) WR is water reducing admixture

2.04 MEASURING, BATCHING, MIXING, AND TRANSPORTING CONCRETE

A. Measuring, batching, mixing and transporting concrete shall conform to ASTM C94 and the requirements herein, or as otherwise approved in writing by the government representative.

B. Ready-mixed concrete, whether produced by a concrete supplier or the removal contractor shall conform to the requirements above. No hand mixing will be permitted.

C. Admixtures shall be dispensed into the batch in conformity with the recommendations of the manufacturer of the admixtures.

D. Concrete shall be mixed until there is uniform distribution of the materials and shall be discharged completely before the mixer is recharged. The mixer shall be rotated at a speed recommended by the mixer manufacturer and mixing shall be continued for at least 1 1/2 minutes after all the materials are in the mixer. Concrete shall be placed within 1 1/2 hours of the time at which water was first added, otherwise it shall be rejected. Concrete which has been remixed or retempered, or to which an excess amount of water has been added, shall also be rejected.

2.05 FORMS

A. Forms shall be free from roughness and imperfections, substantially watertight and adequately braced and tied to prevent motion when concrete is placed. No wooden spreaders will be allowed in the concrete.

B. Wire ties will not be allowed. Metal ties or anchorages which are necessary within the forms shall be so constructed that the metal work can be removed for a depth of at least 1-inch from the surface of the concrete without injury to such surface by spalling or otherwise. Forms shall be thoroughly cleaned before using and shall be treated with oil, or other approved material.

C. All exposed edges of the finished concrete shall be chamfered 3/4-inch.

PART 3 EXECUTION

3.01 REINFORCING STEEL

A. Reinforcing steel shall be accurately fabricated to the dimensions shown. Bars shall be bent around a revolving collar having a diameter of not less than that recommended in ACI 318. All bars shall be bent cold.

B. Unless otherwise shown, splices in reinforcing steel shall be lapped in conformity with ACI 318 but not less than 24 diameters. All bar splices shall be staggered wherever possible. When splicing bars of different diameters, the length of lap is based on the larger bar.

C. Splices in welded wire fabric shall be lapped not less than 1 1/2 courses or 12-inches, whichever is greater. Wire fabric splices shall be tied together with wire ties spaced no more than 24-inches on center. Furnish and install rubber tipped supports to hold wire fabric in the center of the slab.

D. Before being placed in position, reinforcement shall be thoroughly cleaned of loose mill and rust scale, dirt and other coatings, including ice, that reduce or destroy bond. Where there is a delay in depositing concrete after the reinforcement is in place. Bars shall be reinspected and cleaned when necessary.

E. Reinforcement which is to be exposed for a considerable length of time after being placed shall be given a heavy coat of cement grout.

F. In no case shall any reinforcing steel be covered with concrete until the amount and position of the reinforcements have been checked and permission given to proceed by the government representative.

3.02 INSPECTION AND COORDINATION

A. The batching, mixing, transporting, placing and curing of concrete shall be subject to the inspection of the government representative at all times. The removal contractor shall advise the government representative of his/her readiness to proceed at least 24 hours prior to each concrete placement. The government representative will inspect the preparations for concreting including the preparation of previously placed concrete, the reinforcing steel, and the alignment, cleanliness and tightness of formwork. No placement shall be made without the inspection and acceptance of the government representative.

3.03 CONCRETE APPEARANCE

A. Concrete mix showing either poor cohesion or poor coating of the coarse aggregate with paste shall be remixed. If this does not correct the condition, the concrete shall be rejected.

B. Concrete for the work shall provide a homogeneous structure which, when hardened, will have the required strength, durability and appearance. Mixtures and workmanship shall be such that concrete surfaces, when exposed, will require no finishing. When concrete surfaces are stripped, the concrete when viewed in good lighting from 10 feet away shall be pleasing in appearance and at 20 feet shall show no visible defects.

3.04 PLACING AND COMPACTING

A. No concrete shall be placed until forms, condition of subgrade, and method of placement have been approved by the government representative. Before depositing concrete, all debris, foreign matter, dirt and water shall be removed from the forms. The contact surface between concrete previously placed and new concrete shall be cleaned and brushed with cement paste. Concrete, except as indicated on the site-specific work plans, shall not be placed in water or submerged within 24 hours after placing, nor shall running water be permitted to flow over the surface of fresh concrete within 4 days after its placing.

B. Deposit concrete as near its final position as possible to avoid segregation due to rehandling or flowing. Pumping of concrete will be permitted when an approved design mix and aggregate sizes, suitable for pumping, are used. Do not deposit concrete which has partially hardened or has been contaminated by foreign materials. If the section cannot be placed continuously, place construction joints as specified or as approved. Place concrete for walls using tremie tubes in 12- to 24-inch lifts, keeping the surface horizontal. Do not drop concrete more than 4 feet.

C. High frequency mechanical vibrators shall be used to the extent necessary to obtain proper consolidation of the concrete, but not to move or transport concrete in the forms. Care shall be taken to avoid segregation of aggregates by excess vibration. Vibration shall continue until the frequency returns to normal, trapped air ceases to rise and the surface appears liquefied, flattened and glistening. Concrete adjacent to forms and around pipe stubs shall be carefully spaded or rodded.

3.05 CURING AND PROTECTION

A. Protect all concrete work against injury from the elements and defacements of any nature during construction operations.

B. All concrete shall be cured in conformity with ACI 301. Concrete shall be water cured. Water curing shall be by ponding, by continuous sprinkling or by covering with continuously saturated burlap. Other concrete shall be cured by either water curing, sheet material curing or liquid membrane curing compound except that liquid membrane curing compound shall not be used on any concrete surface where additional concrete is to be placed or where the concrete surface is to be coated or painted.

C. Finished surfaces and slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

D. Cold Weather Concreting:

1. "Cold weather" is defined as a period when for more than 3 successive days, the average daily outdoor temperature drops below 40 degrees F. The average daily temperature shall be calculated as the average of the highest and the lowest temperature during the period from midnight to midnight.

2. Cold weather concreting shall conform to ACI 306.1 and the additional requirements specified herein. Temperatures at the concrete placement shall be recorded at 12 hour intervals (minimum).

3. Discuss a cold weather work plan with the government representative. The discussion shall encompass the methods and procedures proposed for use during cold weather including the production, transportation, placement, protection, curing and temperature monitoring of the concrete. The procedures to be implemented upon abrupt changes in weather conditions or equipment failures shall also be discussed. Cold weather concreting shall not begin until the work plan is acceptable to the government representative.

4. During periods of cold weather, concrete shall be protected to provide continuous warm, moist curing (with supplementary heat when required) for a total of at least 350 degree-days of curing.

   a. Degree-days are defined as the total number of 24 hour periods multiplied by the weighted average daily air temperature at the surface of the concrete (e.g., 5 days at an average 70 degrees F = 350 degree-days).

   b. To calculate the weighted average daily air temperature, sum hourly measurements of the air temperature in the shade at the surface of the concrete taking any measurement less than 50 degrees F as 0 degrees F. Divide the sum thus calculated by 24 to obtain the weighted average temperature for that day.

5. Salt, manure, or other chemicals shall not be used for protection.

6. The protection period for concrete being water cured shall not be terminated during cold weather until at least 24 hours after water curing has been terminated.

E. Hot Weather Concreting

1. "Hot weather" is defined as any combination of high air temperatures, low relative humidity and wind velocity which produces a rate of evaporation estimated in accordance with ACI 305R, approaching or exceeding 0.2 pounds/square foot/hour).

2. Concrete placed during hot weather, shall be batched, delivered, placed, cured and protected in compliance with the recommendations of ACI 305R and the additional requirements specified herein.

   a. Temperature of concrete being placed shall not exceed 90 degrees F and every effort shall be made to maintain a uniform concrete mix temperature below this level. The temperature of the concrete shall be such that it will cause no difficulties from loss of slump, flash set or cold joints.

   b. All necessary precautions shall be taken to promptly deliver, to promptly place the concrete upon its arrival at the job and to provide vibration immediately after placement.

   c. The government representative may direct the removal contractor to immediately cover concrete with plastic sheet material.

3. Discuss with the government representative a work plan describing the methods and procedures proposed to use for concrete placement and curing during hot weather periods. Hot weather concreting shall not begin until the work plan is acceptable to the government representative.

F. Concrete placed during hot weather, shall be batched, delivered, placed, cured and protected in compliance with the recommendations of ACI 305R. The temperature of the concrete shall be such that it will cause no difficulties from loss of slump, flash set or cold joints. Immediately cover plastic concrete with sheet material during hot weather.

3.06 FIELD TESTS

A. Sets of four field control cylinder specimens will be taken by the government representative during the progress of the work, in compliance with ASTM C31. The number of sets of concrete test cylinders taken of each class of concrete placed each day shall not be less than one set, nor less than one set for each 150 cubic yards of concrete nor less than one set for each 5,000 square feet of surface area for slabs or walls. One cylinder shall be broken at 3 days, one cylinder at 7 days and two cylinders shall be reserved for additional testing at 28 days or as determined by the government representative. When the average 7 day compressive strength of the cylinders in any set falls below the specified compressive strength or below proportional minimum 7 day strengths (where proper relation between 7 and 28 day strengths have been established by tests); the government representative may reject the concrete represented by the set of cylinders, may require modification of the concrete and/or require modification of the proportions, water content, or temperature conditions of the design mix to achieve the required strengths.

B. Cooperate in the making of tests by allowing free access to the work for the selection of samples, providing an insulated closed curing box for specimens, affording protection to the specimens against injury or loss through his/her operations and furnishing material and labor required for the purpose of taking concrete cylinder samples. All shipping of specimens will be paid for by the government.

C. Slump tests will be made in the field by the government representative in conformity with ASTM C143.

D. Tests for air content shall be made in compliance with either the pressure method complying with ASTM C231 or by the volumetric method complying with ASTM C173.

3.07 STRIPPING AND FINISHING CONCRETE

A. Forms shall not be stripped before the concrete has attained a strength of at least 30 percent of the specified design strength, unless otherwise approved by the government representative. This is equivalent to approximately "100 day-degrees" of moist curing.

B. Care shall be exercised to prevent damaging edges or obliterating the lines of chamfers, rustications or corners when removing the forms or doing any other work adjacent thereto.

C. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete.

D. As soon as forms have been stripped, form ties, if employed, shall be removed, and the recess filled to insure complete watertightness. Any defects in the surface of the walls shall be chipped out and repaired in a workmanlike manner. Defective concrete where it occurs shall be cut to a minimum depth of 1-inch, thoroughly roughened and neat cement brushed in. The hole shall then be filled with mortar in the proportion of 1 part cement and 2 1/2 parts sand with a minimum of water. Mortar for filling form tie recesses shall be mixed to a slightly damp consistency (just short of "balling"), pressed into the recess until dense, and troweled smooth. Mortar in larger patches shall be applied and allowed to assume a partial set following which it shall be struck off flush with the adjoining surface. Patches shall be kept moist for several days to assure proper curing.

E. Top surface of slabs shall be screeded to the established grades and shall be a true plane with a tolerance of 1/8-inch when checked with a 10 foot straightedge. The surface shall be finished to give a smooth, hard, even surface free from high or low spots or other defects. Concrete shall be given a broom finish. Failure to meet the condition shall be cause for removal, grinding, or other approved correction.

F. Concrete Finishes

1. All concrete walkways, driveways and sidewalks shall receive a broom finish.

2. Screed slabs with straightedges to the original grades. When the concrete has stiffened sufficiently to maintain small surface indentations, draw a stiff bristle broom lightly across the surface in the direction of drainage, or, in the case of walks and stairs, perpendicular to the direction of traffic to provide a non-slip surface.

END OF SECTION

SECTION 11

CARPENTRY WORK

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Carpentry work required to restore wood decks, patios, fences, etc. identified in the RAWP and/or shown on the site-specific work plans, or demolition and reconstruction in order to complete soil excavation, shall be completed as specified in this Section.

B. Wood decks, patios, fences or any part of a wood structure not identified for removal and reinstallation or demolition and replacement in kind but damaged by the removal contractor during soil excavation, backfilling and related activities, shall be restored to a condition similar to that which existed prior to removal activities as specified in this Section at the removal contractor's expense.

C. Carpentry work required to restore access openings to a condition that existed prior to removal activities, or to finish access openings as permanent access ports in ceilings, walls and other locations shall be completed as specified in this Section. Access opening may be required in ceilings, walls and other locations in order to complete VCI removal.

D. When carpentry work is required, the removal contractor shall furnish all labor, materials, equipment, and incidentals required to install all items of rough and finish carpentry work required as specified herein.

1.02 SUBMITTALS

A. Submit complete shop drawings showing details of fabrication and erection of all carpentry items and material furnished under this Section.

B. Provide samples of materials proposed for restoration/repair of interior walls, ceilings, floors, etc. and exterior siding for evaluation and approval by the government and property owner prior to initiation of interior removal work.

1.03 REFERENCE STANDARDS

A. American Wood Preservers Association (AWPA)

   1. AWPA P5 - Waterborne Preservatives

B. National Electrical Manufacturers Association (NEMA)

   1. NEMA LD3 - High-Pressure Decorative Laminates

C. Architectural Woodwork Institute (AWI)

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. For finish carpentry items, comply with the specified provisions of the *Architectural Woodwork Quality Standards' Illustrated* of the AWI Premium Grade Standards.

PART 2 PRODUCTS

2.01 MATERIALS - ROUGH AND FINISH CARPENTRY

A. All lumber shall be of sound stock, delivered dry and shall be fully protected at all times from injury and dampness. Split, broken, or otherwise damaged pieces will not be allowed in the work.

B. Wood for blocking and nailers shall be seasoned, 19 percent maximum moisture content, construction grade quality and of Douglas fir, hemlock-fir, southern pine, or ponderosa pine species.

1. Wood members that will contact masonry or concrete shall be vacuum-pressure treated with 100 percent oxide pure chromated copper arsenate meeting AWPA P-5. Minimum net retention of solid preservative shall be 0.40 pounds/cubic feet.

2. All treatment shall be performed in accordance with the requirements of AWPA for treating wood. Apply a heavy coat of the same preservative used in treating to all surfaces cut after treatment.

C. Nails, spikes, bolts, nuts and washers where sizes are not indicated or specified, shall be of suitable size and number as approved to securely fasten and hold members in place. Hot dip galvanize after fabrication.

PART 3 EXECUTION

3.01 FABRICATION - ROUGH AND FINISH CARPENTRY

A. Before proceeding with fabrication of work required to be fitted to other construction, obtain field measurements and verify dimensions and shop drawing details as required for accurate fit.

B. Employ only carpenters experienced in the fabrication and installation of items to be installed.

3.02 INSTALLATION

A. All rough and finish carpentry shall be accurately cut, fitted and installed to match existing.

B. Anchors shall be installed, where indicated or required, to anchor carpentry or other items securely to masonry or concrete.

C. Provide all miscellaneous wood formwork as may be required for the completion of concrete work.

D. Install carpentry work in a manner consistent with quality of specified grade to be plumb, level, true and straight with no distortions.

3.03 ACCEPTANCE CRITERIA

A. Upon completion of the carpentry work, the A&E will conduct a property inspection and determine if the materials used in the restoration work are equivalent to those which existed before providing access to removal areas.

END OF SECTION

SECTION 12

INSULATION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The work of this section includes insulating attics, knee walls, exterior walls and other locations identified in the site-specific work plans.

B. Insulation installation shall not begin until the area to be insulated has been clearance sampled and the EPA clearance criteria is met.

C. The removal contractor will furnish and install all blown-in insulation, batt type insulation, ventilation materials and related work necessary to provide a complete insulation of the areas in the structure from which VCI has been removed.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in original sealed containers or packages, each bearing manufacturer's name and brand designation, referenced specification number, type, and class, as applicable; recommended method of installation (pneumatic or pouring); minimum net weight of insulation; coverage charts; and R-values.

B. Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.03 SAFETY PRECAUTIONS

A. The removal contractor must ensure that personnel are trained in and use appropriate health and safety precautions during installation.

B. Do not smoke during installation of loose fill thermal insulation.

C. Consider other safety concerns and measures as outlined in ASTM C 930.

PART 2 PRODUCTS

2.01 LOOSE FILL INSULATION

A. In general, loose fill (blown-in) fiberglass insulation will be used in attics and exterior walls as described in the site-specific work plans.

B. Loose-fill (blown-in) fiberglass insulation shall be Type 1 as described in ASTM C764. Surface burning characteristics shall meet the requirements of ASTM E84 with a flame spread of 5 and a smoke developed of 5. Blown-in type shall be noncombustible as per ASTM E136.

C. Loose fill insulation shall be ProPink Complete Blown-in Wall System as manufactured by Owens Corning, Attic Protector or Climate Pro as manufactured by Johns Manville, InsulSafe 4 Fiber Glass Blowing Insulation or Optima Loose Fill Fiber Glass Insulation for Sidewall Reinsulation as manufactured by CertainTeed or equal.

2.02 FIBERGLASS BATT INSULATION

A. Fiberglass batt insulation shall be used in specific locations identified in the site-specific work plans.

B. Batt type fiberglass insulation shall be provided in the width and thickness necessary to fit firmly between ceiling joists, floor joists or wall studs without slippage. Fiberglass batt insulation shall be provided with or without kraft facing, as agreed upon between the government and the property owner. Fiberglass batt insulation shall meet Building Officials and Code Administrators (BOCA) building code standards and ASTM C665 material standards and ASTM C518 for thermal performance. Unfaced fiberglass batt insulation shall comply with ASTM E84 for fire resistance with a maximum flame spread index of 25 and a maximum smoke developed index of 50.

C. Fiberglass batt insulation shall be ProPink FastBatt Fiberglass Insulation as manufactured by Owens Corning, Kraft-Faced Thermal and Acoustical Fiber Glass Insulation as manufactured by Johns Manville, Kraft-Faced Fiber Glass Building Insulation as manufactured by CertainTeed Corporation, or equal.

2.03 R-VALUES

A. Attic floors, attic-within-attic areas, kneewall flooring, etc. shall have a minimum insulation R-value of R-38.

B. Walls, crawlspaces, basements, etc. shall have a minimum insulation R-value of R-19.

C. In the event that the insulation removed from the attic has an R-value greater than R-38, the removal contractor will restore the attic using an insulation amount to match the R-value removed.

2.04 PROHIBITED MATERIALS

A. ACM

B. Urea Formaldehyde containing materials

C. Ammonium Sulfate containing material

2.05 SILL SEALER INSULATION

A. Sill sealer insulation, if required shall meet the requirements of ASTM C 665, Type I.

2.06 BAFFLES

A. Baffles shall be wood, metal, or unfaced mineral fiber blanket material in accordance with ASTM C 665, Type I. Blocking to prevent blown-in insulation from obstructing roof ventilation shall be Johns Manville AP Foil-Faced Polyisocyanurate Foam Sheathing or equal.

B. Provide only non-combustible materials based on determination by ASTM E136 for blocking around chimneys and heat producing devices.

C. Provide rigid foam baffles and other accessories from the blocking manufacturer that allow continuous ventilation from the soffit to the roof ridge.

2.07 VAPOR RETARDER

A. In encapsulated areas where there had been a vapor retarder prior to VCI removal, the removal contractor will install a vapor retarder. The vapor retarder will meet the following specifications:

1. 6-mil thick polyethylene sheeting conforming to ASTM D4397 and having a water vapor permeance of 0.20 perm or less when tested in accordance with ASTM E96, or equivalent material approved by the A&E.

2.08 PERIMETER INSULATION

A. Rigid perimeter insulation shall be installed on the exterior of foundation and basement walls where existing insulation was removed or damaged during contaminated soil removal.

B. Perimeter insulation shall be 2-inch extruded closed cell polystyrene foam board with integral high density skins of same material. Insulation shall have a K factor of 0.20 at 75 degrees F and 0.18 at 40 degrees F. Density shall be 1.7 pounds/ft^3 maximum with a compressive strength of 20 pounds per square inch (psi) minimum. Water absorption shall be 0.7 percent maximum with a water vapor transmission of 0.6 perm-in maximum. Rigid insulation shall be waterproof and non-water absorbing. Rigid insulation shall be Styrofoam Brand Insulation as manufactured by the Dow Chemical Company or approved equal.

PART 3 EXECUTION

3.01 EXISTING CONDITIONS

A. Before installing insulation, confirm with the government representative that all areas of the attic, walls, knee walls or other locations from which VCI has been removed have passed clearance testing. If moisture or other conditions are found that do not allow the workmanlike installation of the insulation, do not proceed but notify the government representative immediately of such conditions.

3.02 PREPARATION

A. Baffles at Attic Vents and Access Doors

1. Prior to installation of blown-in insulation, install permanent baffles to prevent insulation from covering, clogging, or restricting air flow through soffit vents at building eaves. Install permanent baffles around attic accesses. Baffles and required accessories shall be furnished and installed in a manner such that there is a continuous pathway along the underside of the roof from the soffit ventilation to the roof ridge. The removal contractor must contact the A&E prior to insulation installation, so that an inspection of the baffling may be performed.

   Baffles are to be installed at building eaves regardless of whether there is an existing ventilation system or not.

B. Baffles Around Heat Producing Devices

1. Install non-combustible baffles around heat producing devices to provide the following clearances:

2. Recessed lighting fixtures, including wiring compartments, ballasts, and other heat producing devices, unless certified for installation surrounded by insulation: 3-inches from outside face of fixtures and devices or as required by National Fire Protection Association (NFPA) 70 and, if insulation is to be placed above fixture or device, 24-inches above fixture.

3. Masonry chimneys or masonry enclosing a flue: 2-inches from outside face of masonry. Masonry chimneys for medium and high heat operating appliances: Minimum clearances required by NFPA 211.

4. Vents and vent connectors used for venting the products of combustion, flues, and chimneys other than masonry chimneys: minimum clearances as required by NFPA 211.

5. Gas fired appliances: Clearances as required in NFPA 54.

6. Oil fired appliances: Clearances as required in NFPA 31.

7. Baffles around flues and chimneys is not required if the insulation and vapor retarder, when provided, passed ASTM E 136, in addition to meeting all other requirements stipulated in Part 2. The baffles are also not required when chimneys are certified by the manufacturer for use in contact with insulating materials.

C. Protection of Ventilation System

1. Prior to installation of insulation, inspect existing HVAC equipment and ductwork to ensure that insulation will not infiltrate the air distribution/ventilation system. Where potential infiltration sources have been identified, do not install insulation until repairs/modifications have been made to rectify the problem. Removal contractor will furnish and install all necessary accessories recommended by the insulation manufacturer so that the completed insulation work does not block ventilation pathways.

3.03 INSTALLATION

A. The removal contractor must inform the A&E when insulation installation is to begin.

B. Store, handle and install insulation in strict accordance with manufacturer's instructions. Keep material dry and free of extraneous materials. Removal contractor will be responsible for providing personal protective clothing and respiratory equipment recommended by the insulation manufacturer and to be sure this equipment is used by his installers at all times insulation work is in progress. Observe safe work practices. Use only pneumatic equipment compatible with insulation material. Operate equipment in accordance with the manufacturer's instructions. Do not tamp or rod insulation. Install insulation using the amount (by weight) of material per square foot required by the insulation manufacturer to achieve the specified R-value.

C. Replace insulation in attic areas where VCI removal has been completed and, if necessary, in other areas to provide the specified minimum R-value. For pneumatic installations, use lowest air pressure allowed by manufacturer's instructions. Do not blow insulation into electrical devices, soffit vents, or mechanical vents which open into attic or other spaces to provide ventilation.

D. Under no circumstance shall baffles restrict a continuous ventilation pathway from the soffit vent to the roof ridge vent, gable end vents, or other attic ventilation ports. Provide baffles and other accessories from the manufacturer for this purpose. Baffles shall not be in direct contact with the roof.

E. Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

F. Place insulation under electrical wiring occurring across ceiling joists. Pack insulation into narrowly spaced framing. Do not block flow of air through soffit vents.

G. Affix blanket insulation to all access panels and doors greater than 0.1 square meter (one square foot) in insulated floors and ceilings. Use insulation with same R-value as that for floor or ceiling.

H. Apply continuous vapor retarder in accordance with manufacturer's installation instructions. Do not install vapor retarders on both sides of insulation.

END OF SECTION

SECTION 13

DEMOLITION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment and incidentals required to demolish/dismantle and dispose of the buildings and structures, pavements, slabs, and other property improvements as indicated on the site-specific work plans.

B. The removal contractor will furnish all labor, material, equipment and incidentals required to remove, contain and properly transport and dispose of hazardous and regulated materials from the buildings and property prior to demolition as indicated on the site-specific work plans.

C. A&E personnel will conduct a pre-demolition investigation of each building and property improvement to be demolished. The findings of the pre-demolition investigation will be included in the site-specific work plans.

D. During the pre-demolition investigation A&E personnel will coordinate with the property owner and the Volpe Center to identify building contents to be disposed, building contents to be removed and stored by the property owner, and building contents to be stored temporarily on behalf of the property owner. The disposition of listed items will be provided in the site-specific work plans. Items not removed from the building by the property owner at the time demolition is to begin, will be removed and disposed of by the removal contractor as part of the demolition work.

E. The government may require bulk removal of VCI prior to building demolition. If required, VCI shall be removed from locations indicated on the site-specific work plans.

F. Blasting and the use of explosives will not be permitted for any demolition work.

G. The removal contractor must incorporate demolition specific recommendations provided by EPA, Volpe, and A&E H&S as they relate to equipment selection, dust control, and material handling.

1.02 SUBMITTALS

A. Submit to the Volpe Center a demolition schedule and biweekly demolition schedule updates.

1.03 JOB CONDITIONS

A. Protection

1. Execute the demolition and removal work to prevent the deposition of ACM, dust, debris, stormwater runoff, or dust suppression water outside the limits of work.

2. The removal contractor shall protect all overhead utilities and known subsurface utilities identified on the site-specific work plans.

B. Conditions of Structures

1. The EPA, Volpe Center, and A&E assume no responsibility for the actual condition of the structures to be demolished. The removal contractor shall be aware that many of the buildings and structures may be in an advanced state of deterioration. The condition of the buildings shall not relieve the removal contractor of the responsibility for performing the dismantling, demolition, and decontamination work safely and in accordance with the specifications.

C. Damage Repair

1. Promptly repair damage caused to adjacent structures, structures to be protected, facilities or utilities by demolition operations at no additional cost to EPA and the government. Repairs shall be made to restore any damaged items to a condition equal to that which existed prior to demolition.

D. Traffic Access

1. Conduct demolition operations and the removal of demolition debris in a manner such that there is minimum interference with public roads.

2. Do not close or obstruct streets, walks or other facilities without permission from the Volpe Center, A&E H&S, and the applicable Police Department. Furnish alternate routes around closed or obstructed traffic in access ways.

1.04 REGULATORY REQUIREMENTS

A. All work shall be performed in accordance with all applicable federal, state, and local regulations, laws, codes, and ordinances governing demolition and the handling, transportation and disposal of solid waste and asbestos waste, hazardous chemicals and materials, and liquid wastes.

B. The removal contractor shall obtain all necessary non-environmental permits and approvals required to perform the demolition, transportation, and disposal.

1.05 DISPOSAL REQUIREMENTS

A. No material or equipment within the limits of demolition shall become the removal contractor's property. Salvage of steel and other metals for reprocessing is not allowed.

B. The unlined Asbestos Landfill at the Lincoln County Landfill Facility is classified by ARM 17.50.504 as a Class IV Landfill. Class IV Landfills in Montana are permitted to accept only Group III or Group IV Wastes. Group III Wastes as described in ARM 17.50.503 include wood wastes and non-water soluble solids. Group III wastes are characterized by their general inert nature and low potential for adverse environmental impacts. Examples of Group III Solid Wastes include, but are not limited to,

1. Inert solid waste such as unpainted brick, dirt, rock and concrete

2. Clean, untreated, unglued wood materials, brush, unpainted or untreated lumber, and vehicle tires

3. Industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents

Group IV Wastes include construction and demolition wastes, and asphalt, except regulated hazardous wastes.

C. The removal contractor must obtain approval for all disposal locations prior to a material's disposal.

D. The removal contractor shall prepare manifests for transportation and disposal of hazardous and regulated materials removed from the building(s) or property. The government will be the waste generator for manifesting purposes, and will sign all hazardous waste manifests and solid waste shipping and record logs. Provide the Volpe Center with the proper copies of the written manifests and logs verifying receipt of each load at the disposal facilities, the quantity received (volumes and weights as necessary), and verification of proper disposal.

E. The removal contractor shall assign a single, specific employee to prepare manifests, track disposal, inspect waste loads, and act as the Volpe Center contact for all transportation and disposal issues.

F. The removal contractor shall dispose of all demolition debris and VCI at the Class IV Asbestos Landfill located at the Lincoln County Landfill unless directed otherwise by the Volpe Center or A&E H&S.

PART 2 EXECUTION

2.01 GENERAL

A. Work Sequence

1. Meet with the Volpe Center to review the site-specific work plans and schedule for demolition sampling and related activities. The removal contractor must coordinate all demolition activities with sampling scenario requirements defined by EPA.

2. Establish work zones and temporary facilities at the demolition site.

3. Identify and disconnect overhead and underground utilities.

4. Remove items from the building that are to be stored on behalf of the property owner or disposed.

5. Remove hazardous and regulated materials from the building and dispose at facilities licensed to accept the various types of wastes.

6. Relocate sheds, support buildings and other property improvements to be protected during demolition activities.

7. Perform bulk removal of VCI if required from locations identified in the site-specific work plans.

8. Demolish/dismantle the building(s), pavements, and other property improvements identified in the site-specific work plans.

9. Transport demolition debris and dispose of at the Class IV Asbestos Landfill.

2.02 DEMOLITION/DISMANTLING

A. Demolish all structures within the horizontal limits of work to the vertical limits identified in the site-specific work plans. Transport and dispose of all materials generated during decontamination and demolition as specified herein, and in accordance with all applicable laws and regulations.

B. Unless otherwise approved by the Volpe Center, proceed with demolition from the top of each structure to the ground. Complete demolition work above each floor or tier before disturbing supporting members of lower levels. Unless approved by the Volpe Center, complete demolition of each structure before beginning demolition on subsequent structure.

C. Remove structural framing members by methods suitable to avoid dust generation. Use water mist, temporary enclosures, and other suitable methods to limit the production of dust during demolition operations. The removal contractor shall provide all water for dust control, personnel, equipment decontamination, and other uses during the performance of the work.

2.03 LIMITS OF DEMOLITION

A. The horizontal limits of demolition shall consist of all aboveground structures within the limits of demolition shown on the drawings. The structures to be demolished include houses, storage buildings, offices, machinery, equipment, tanks, and other miscellaneous items.

B. Demolish and dispose of all discarded or stored scrap metal items, raw materials in containers, lumber, building materials, and other miscellaneous items within the limits of demolition. Removal and disposal of preexisting uncontainerized piles of soil, vermiculite, or trash outside the building footprints, are included in the work.

C. Except as specifically noted on the site-specific work plans, the vertical limits of demolition shall consist of each structure and all attached and enclosed machinery, equipment, appurtenances, waste, and debris down to the following limits:

1. Foundations and footings to bottom of footing

2. Slab-on-grade structures to the bottom of slab

3. Wood, block or brick floor areas: remove floor and subgrade to 1 foot below first floor bottom elevation

2.04 SITE PREPARATION

A. Prior to commencement of demolition activities at each building or structure the following preparation activities shall be performed at a minimum.

1. Install runoff containment and collection facilities as specified in Section 5 of these Construction Specifications.

2. Install dust control equipment and temporary facilities in accordance with the removal contractor's approved demolition plan.

3. Isolate and disconnect all water supply connections, electric service, natural gas service, sewer service, cable TV service, etc.

4. Isolate and plug all the onsite septic piping originating within the building. Line shall be permanently plugged at its point of discharge from the building, or at the nearest accessible point downstream.

B. Prior to the commencement of demolition near abutting properties, erect temporary protection systems, including temporary shoring, if necessary.

C. Prior to the commencement of demolition operations, erect new security fencing and initiate site security operations as specified in Section 2 of these Construction Specifications.

2.05 DECONTAMINATION

A. The site-specific work plan for a property to be demolished will include descriptions and locations for bulk removal of VCI if required. The site-specific work plan will also include a list, accurate as of the date of inspection, of items requiring decontamination or special handling and disposal prior to building demolition. Examples include white goods such as refrigerators and air conditioners which will require removal of refrigerants prior to decontamination and disposal at the Lincoln County Landfill or removal of refrigerants and disposal at the Class IV Asbestos Landfill as ACM.

B. Items requiring decontamination shall be HEPA vacuumed or wet wiped as appropriate. It is not intended that the removal contractor necessarily remove encrusted or well-adhered material during the decontamination operations. Decontamination required for a building to be demolished shall be considered complete when all such loose material has been removed from all accessible surfaces, as determined by visual inspection.

C. Prior to demolition of the buildings, the removal contractor shall also remove and dispose of all waste piles consisting of dust, vermiculite, or other granular or particulate matter, scrap metal, rubble, debris or building materials as part of the decontamination work.

2.06 PETROLEUM STORAGE EQUIPMENT

A. Remove and dispose of all fuel oils, hydraulic oils, oil sludges, and other petroleum products from equipment, pipelines, and tanks prior to demolition. A material handling and disposal plan must be provided to A&E H&S prior to the start of site work.

B. Demolish all petroleum storage tanks and appurtenances in accordance with State of Montana and city of Libby environmental and fire prevention regulations. Obtain permits for demolition of petroleum equipment where appropriate.

2.07 DUST CONTROL

A. The removal contractor shall implement dust control measures before, during, and after demolition activities. Dust control measures shall be performed during VCI removal, decontamination, demolition, handling, processing, loading, and all other site work activities. No visible dust emissions shall be permitted during demolition activities and related work.

B. The removal contractor shall not increase dust suppression water flow beyond that necessary to control dust, such that excessive water is generated during the conduct of the work. The removal contractor shall implement Stormwater, Sedimentation and Erosion Control as specified in Section 5.

2.08 PROCESSING, LOADING, AND DISPOSAL

A. All materials and waste generated as a result of VCI removal and demolition operations shall be disposed of at the Class IV Asbestos Landfill unless directed otherwise by the Volpe Center or A&E H&S.

B. The removal contractor shall conduct demolition and loading operations such that the rate of loading and removal generally equals the rate of generation of demolition waste. The removal contractor shall proceed with loading and disposal of demolition and decontamination waste in the general order of its generation, such that the storage of waste does not exceed any established regulatory limit. Stockpiling of demolition debris shall not be permitted, unless approved by the Volpe Center.

C. Furnish, install, and maintain any temporary loading facilities, staging facilities, and parking areas required for the completion of waste removal activities.

D. All vehicles shall be decontaminated prior to leaving the removal contractor's established exclusion zones. Decontamination shall be sufficient to remove all dust, soil, or waste materials. At the site boundaries all vehicles leaving the site shall be inspected by the removal contractor to ensure that no excess dust is present, and no soil or material adheres to wheels or undercarriage. All excess dust, soil, and any waste material that is visible shall be removed from the waste hauling vehicles before leaving the site.

E. The removal contractor shall have full responsibility for, and control over the movement of waste from the site to the disposal facilities, and for regulatory compliance during transit, whether it be performed directly by the removal contractor's equipment and personnel, or by subcontract to a third party transporter.

F. The removal contractor shall prepare manifests for transportation and disposal of each load. The government will be the waste generator for manifesting purposes, and will sign all hazardous waste manifests and solid waste shipping and record logs. Provide the Volpe Center with the proper copies of the written manifests and logs verifying receipt of each load at the disposal facilities, the quantity received (volumes and weights as necessary), and verification of proper disposal. The removal contractor shall assign a single, specific employee to prepare manifests, track disposal, inspect waste loads, and act as the Volpe Center contact for all transportation and disposal issues.

G. The removal contractor shall be responsible for any and all actions necessary to remedy situations involving waste spilled in transit.

H. Routes and timing must be coordinated with appropriate state and local regulatory agencies. While involved in the performance of the work under contract, and while not in transit, all waste transportation vehicles must be stored within the site boundaries or established exclusion zone. Under no circumstances shall the removal contractor use public roadways or public parking areas for vehicle parking or staging.

END OF SECTION

SECTION 14

RESIDENTIAL EARTHWORK

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, supervision, materials, equipment, tools, permits, and incidentals necessary to perform excavation, filling, backfilling, and grading of the areas shown on the site-specific work plans and specified herein, plus any additional excavation required for establishment of operations. The work as described under this Section shall include all excavation, backfilling, compacting, grading, and related work at properties requiring removal of contaminated soil.

B. During construction, all excavation, filling, backfilling, and grading shall be performed in a manner and sequence that will avoid damage to existing properties, houses, fences, decks, barbecue grilles, privacy screens, lawn ornaments, sprinkler systems, streets or other features adjacent to the work areas.

C. Dust control shall be maintained by the removal contractor at all times.

D. Topsoil and common fill will be provided by the government and stockpiled at several locations in the Libby area.

E. The removal contractor shall provide structural fill.

F. Landscaping will be completed under a separate government contract.

1.02 REFERENCE STANDARDS

A. ASTM

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils

2. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil using Modified Efforts (56,000 foot pound force/ft^3) (2,700 kN-m/m^3)

3. ASTM D2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

4. ASTM D2974 - Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

5. ASTM D3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

6. ASTM D3740 - Standard Practice for Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as used in Engineering Design and Construction

7. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

B. OSHA 29 CFR Part 1926, Construction Industry.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 QUALITY ASSURANCE

A. The removal contractor shall be responsible for the quality of work and materials during earthwork operations and any settlement of backfill materials. The A&E will verify the adequacy of site preparation and acceptability of available fill material; and will observe the placement and compaction of all fill material. All work found unsatisfactory shall be corrected in an approved manner at no additional cost to the government.

PART 2 PRODUCTS

2.01 GENERAL

A. The removal contractor will provide all materials and equipment in suitable and adequate quantity and quality as required to accomplish the work identified in the site-specific work plans and specified herein.

B. Topsoil and common fill will be made available to the contractor by the government. The removal contractor shall be responsible to provide all structural fill in accordance with the specifications. The removal contractor shall be solely responsible for modifications to the moisture content of all materials required to achieve the specified compaction. The Volpe Center is not responsible to maintain any specific level of moisture in the soil at its stockpiled location.

C. Provide all water necessary to control dust on the property and roadways adjacent to the property, all water necessary for thorough compaction of backfill materials, and all other water needs to complete the work of this section.

2.02 COMPACTION EQUIPMENT

A. Compaction equipment shall be of suitable type and adequate to obtain the densities specified, and shall provide satisfactory breakdown of materials to form a dense fill. Acceptable compaction equipment shall consist of pneumatic tire, tamping foot, sheepsfoot rollers or vibratory plate compactors unless the removal contractor can demonstrate, to the satisfaction of the Volpe Center, that other equipment will produce satisfactory results.

B. Compaction equipment shall be operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it will deliver the manufacturer's rated compactive effort. If specified densities are not obtained, larger and/or different types of additional equipment shall be provided by the removal contractor. Hand-operated equipment shall be capable of achieving the specified densities.

C. The removal contractor must notify A&E oversight of planned backfilling activities, in order to coordinate A&E evaluations of grading and compaction performed by the removal contractor.

2.03 MOISTURE CONTROL EQUIPMENT

A. Equipment for applying water shall be of a type and quality adequate for the work, shall not leak, and shall be equipped with a pressurized distribution system to assure uniform application. Equipment for disking and drying out material shall consist of blades, discs, or other approved equipment.

2.04 STRUCTURAL FILL

A. Structural fill for use as sub-base in gravel driveways and gravel roads shall consist of an angular, hard, durable, processed, crushed gravel conforming to the requirements of the State of Montana Department of Transportation standard 701.02.5 Crushed Base Course Type "B," Grade 2.

B. Structural fill shall have no particles larger than 1½ inches in largest dimension and conform to the following gradation:

Sieve Size	**Percent Finer by Weight**
1½ inches	100
No. 4	25 to 55
No. 200	0 to 8

END OF SECTION

SECTION 15

VERMICULITE-CONTAINING INSULATION REMOVAL

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This specification applies to the removal, transport, and disposal of VCI from specific locations in buildings to be re-occupied after VCI removal as identified in this task order. The work addressed in this section shall be performed in accordance with all applicable federal, state and local regulations pertaining to asbestos containing materials.

B. VCI removal from locations within the building(s), as identified in the site-specific work plans; site preparation, site security; equipment and personnel decontamination facilities; cleaning, temporarily storing and returning the property owner's furnishings and other items in identified removal areas; protection of the building, such as walls, floors, ceilings; dust suppression; clean up; and restoration of properties to be re-occupied.

C. This specification also applies to the bulk removal, transport and disposal of VCI from structures identified for demolition. Work performed under this specification shall be performed in accordance with all applicable federal, state and local regulations prior to beginning demolition of the structure.

D. All other potential ACMs including floor tile, transite board, roofing materials, etc. are considered to be Class II asbestos under the OSHA Standard 29 CFR 1926.1101 and shall be disposed as part of the demolition debris. During the demolition removal of these ACMs, the work area shall be isolated and engineering controls implemented by the removal contractor in accordance with this OSHA Standard.

E. The removal contractor will furnish all labor, materials, equipment and incidentals required to remove and dispose of all VCI from specifically identified locations such as attics, crawlspaces, wall cavities in residential, commercial, industrial and public buildings. The work also includes removal and disposal of ceiling, wall and floor materials removed from the buildings in order to access the VCI. The materials removed from the properties and demolition debris shall be handled as asbestos contaminated material.

F. The removal contractor shall be responsible for containing all removed VCI and other asbestos contaminated material resulting from VCI removal and related work in appropriate vehicles such as vacuum trucks or roll-off containers, fitted with air tight, leakproof covers.

G. The removal contractor shall be responsible for managing the removal activities in a manner such that free liquids or free draining liquids are not present in the waste.

H. Transport and disposal of VCI and other ACM shall be in accordance with the Transport and Disposal Section of these Construction Specifications.

PART 2 PRODUCTS

2.01 RESPIRATORY PROTECTION

A. The removal contractor shall provide respirators to all workers working in the regulated area. All respiratory protection programs shall be established in accordance with the Libby CSHASP and the respiratory protection requirements of 29 CFR 1910.134, 29 CFR 1926.58(h), and 29 CFR 1926.103. Adherence to these regulations shall be considered as a requirement of these specifications.

2.02 ELECTRICAL EQUIPMENT

A. Provision of temporary power inside the work area may create additional hazards. OSHA considers removal action projects under 29 CFR 1926, Subpart K (in particular, Sections 404, 405, 416, and 477). There are special requirements for supplying temporary power. This shall be done by supplying power through Ground Fault Circuit Interrupters (GFCI). Use of GFCIs to protect all circuits provides the safest power source since any significant current leakage will trip the circuit. These devices prove most effective when kept outside the work area away from the high humidity. An assured equipment grounding program requires regular inspection of all tools, cords, and electrical devices with written documentation maintained.

B. Lights, vacuum cleaners, negative air systems, drills, saws, heaters, etc. shall be inspected by the removal action contractor regularly for damage, proper grounding, and integrity of insulation. All identified deficiencies will be taken off line immediately and repaired or replaced before being used again on the project.

C. Extension cords used with portable electric tools and appliances must be the three wire type and connected to a GFCI circuit. Extension cords shall be protected from accidental damage, and shall not be fastened with staples, hung from nails, or suspended by wire.

D. Portable electric hand tools shall be equipped with a 3-wire cord having a ground wire permanently fixed to the tool frame, or be of the double insulated type and labeled as such.

E. Extension cords used to power equipment and tools, which are not on a GFCI circuit must be removed from the work area <u>or</u> deenergized at the end of each work shift. Non-GFCI equipment may not remain energized when removal contractor supervisory personnel are not on the job site.

2.03 SCAFFOLDING

A. This project may require the use of scaffolding on a case-by-case basis. Proper set up, regular inspections, and basic maintenance shall not be overlooked. All scaffolding used during this project shall conform to the requirements of 29 CFR 1910.28, 29 CFR 1910.29, and 29 CFR 1926.451.

B. All scaffolding will be securely fastened to the structure it is intended to service.

C. In many removal projects manually propelled mobile scaffolding provides a convenient and efficient work platform. Federal regulations (29 CFR 1926.451) requires that when free standing mobile scaffolding is used, the height shall not exceed four times the minimum base dimension. This requirement is based on the fact that scaffolding is easily turned over. Since relatively little force is required to tip a scaffold, it becomes critically important to make sure that wheels on mobile scaffolds move freely and are in good repair.

D. If rented scaffolding is used, all components shall be inspected prior to accepting it. Wheels shall turn freely and be lubricated. All components such as cross bracing, railings, pin connectors, planking or scaffold grade lumber shall be available before the units are assembled.

E. When workers ride on mobile scaffolding the removal action contractor shall insure the following conditions exist.

1. The floor or surface is within 3-inches of level, and free from pits, holes, or obstructions.

2. The minimum dimension of the scaffold base, when ready for rolling, is at least one-half of the height. Outriggers, if used, shall be installed on both sides of staging.

3. The wheels are equipped with rubber or similar resilient tires.

4. All tools and materials are secured or removed from the platform before the mobile scaffold is moved.

F. Guardrails and toeboards shall be installed on all open sides and ends on scaffolds more than 10 feet above the ground or floor. Scaffolds 4 feet to 10 feet in height, having a minimum horizontal dimension in either direction of less than 45 inches, shall have standard guardrails installed on all open sides and ends of the platform.

G. Planking used on scaffolds shall extend over their end supports not less than 6 inches or more than 12 inches, and be secured from movement.

H. The removal contractor shall be solely responsible for the erection and use of all scaffolding used during the project.

2.04 POLYETHYLENE SHEETING

A. Polyethylene sheeting used to build containment areas or decontamination chambers shall be a minimum thickness of 6-mils. All polyethylene sheeting shall be used in widths selected to minimize the frequency of joints. Opaque polyethylene sheeting shall be used for worker decontamination units, mini-enclosures, or other structures requiring privacy.

B. Methods of attaching polyethylene sheeting will be agreed upon in advance by the removal contractor and the Volpe Center. Methods of attachment may include any combination of duct tape or other waterproof tape, furring strips, spray adhesive, staples, nails, screws, or other effective procedures capable of sealing adjacent sheets of polyethylene sheeting to dissimilar finished or unfinished surfaces under both wet and dry conditions.

2.05 ASBESTOS WASTE DISPOSAL BAGS

A. Asbestos waste disposal bags shall be constructed of 6-mil transparent polyethylene. Transparent bags are specified so that post-bagging visual inspection can determine if the bagged waste is properly wetted and that the waste has been double-bagged properly. Disposal bags shall be preprinted with labels as required by EPA, OSHA, and DOT regulations.

2.06 ASBESTOS WASTE DISPOSAL DRUMS

A. Asbestos waste disposal drums shall be of metal or fiberboard with locking ring tops and labeled in accordance with the requirements of the OSHA Hazard Communications Standard 29 CFR 1926.59(f). Warning signs that meet the requirements of 29 CFR 1926.58 (k)(1) shall also be posted on the drums.

2.07 SURFACTANT OR WETTING AGENT

A. Asbestos Surfactant or wetting agent shall be a 50/50 mixture of polyoxyethylene ether and polyoxyethylene ester, or equivalent, mixed in a proportion of 1 fluid ounce to 5 gallons of water, or as specified by the manufacturer.

2.08 AIRLESS SPRAYERS

A. Airless sprayers with pumps capable of providing 500 pounds per square inch (psi) at the nozzle tip at a flow rate of 2 gallons per minute for spraying amended water shall be provided and used. ANSI approved vacuum cleaners equipped with HEPA filters shall be provided and used.

2.09 HEPA FILTRATION SYSTEMS

A. HEPA filtration systems brought to the project site shall be uncontaminated and equipped with new filters. All filtration equipment shall be in compliance with ANSI Standard Z9.2-79, local exhaust ventilation. The removal contractor's competent person shall inspect both the interior and exterior of each filtration unit to determine the unit's integrity.

2.10 WARNING SIGNS

A. To protect the public, the removal contractor shall comply with 29 CFR 1926.58(k)(1) by posting safety warning signs at the perimeter of the regulated area (minimum size of 12 inches x 18 inches with black letters on a red and white background) that follow the sample format shown here.

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE
CLOTHING ARE REQUIRED IN THIS
AREA

2.11 OTHER EQUIPMENT

A. The removal contractor shall provide all other equipment required to complete this removal action. This equipment may include, but is not limited to heavy equipment, hand tools, wood, fasteners, etc.

2.12 ENCAPSULANTS, SEALANTS AND CAULKING

A. Lock-down encapsulant used for sealing cleaned, caulked and foamed surfaces shall be formulated from acrylic polymers to provide a durable barrier over building surfaces to prevent residual asbestos fibers from becoming airborne. Lock-down encapsulant shall be CONTROL Lock-Down Encapsulant as manufactured by Grayling Industries, Inc. of Alpharetta, GA or approved equal.

B. Multi purpose encapsulant used for cleaned surfaces and air misting shall be formulated from (vinylidene fluoride) polymers blended with flame retardants to provide a durable barrier over building surfaces to prevent residual asbestos fibers from becoming airborne. Multi purpose encapsulant shall be CONTROL Multi-Use Encapsulant as manufactured by Grayling Industries, Inc. of Alpharetta, GA or approved equal.

C. Insulating foam sealant for sealing gaps, cracks, and around windows and doors, electrical outlets, switches and fixtures shall be polyurethane foam based, Class 1 foam, UL listed as fire retardant. Insulating foam sealant shall be Great Stuff as manufactured by Dow Chemical Company or approved equal.

D. Caulking shall be one part, gun grade, silicone base sealant formulated specifically for interior or exterior use as required. Silicone caulking shall be as manufactured by General Electric, Dow Corning or approved equal.

2.13 SUBSTITUTIONS

A. The Volpe Center will consider requests for substitutions of materials, equipment, and methods only when such requests are accompanied by full and complete technical data and all other information required by the Volpe Center to evaluate the proposed substitution. The removal contractor shall not substitute materials, equipment, or methods unless such substitution has been approved for this work by the Volpe Center.

PART 3 EXECUTION

3.01 VCI CONTAINMENT

A. In general, VCI removed from attics, walls and other locations shall be stored in air tight roll-off containers or vacuum trucks.

B. VCI not stored in air tight roll-off containers or vacuum trucks shall be stored in drums or double bags.

C. The removal contractor shall be responsible for bagging, containing and handling VCI and other removed ACM removed by vacuum from wall cavities, attics, and other locations during interior removals in a manner that prevents the release of asbestos fibers.

D Any debris or residue observed on containers or surfaces outside of the work area resulting from clean up or disposal activities shall be immediately cleaned up using HEPA filtered vacuum equipment and/or wet methods as appropriate.

E. The removal contractor shall be responsible for implementing pollution control measures throughout the removal activities. Trucks, vehicles and equipment shall be fueled and lubricated offsite or in a controlled manner. The removal contractor shall be responsible for conducting its operations such that there are no uncontrolled spills of fuel, oil, lubricants, chemicals, etc. to the ground or surface waters. Should a spill occur, the removal contractor shall, at its expense, perform all cleanup operations as required by federal, state or local regulations.

3.02 REGULATORY REQUIREMENTS

A. The removal contractor will complete all work in this specification according to the Safety and Health Standards for the Construction Industry Title 29, Part 1926 of the Code of Federal Regulations (29 CFR 1926), Occupational Safety and Health Standards for General Industry Title 29 Part 1910 of the Code of Federal Regulations (29 CFR 1910), applicable sections of Protection of the Environment (40 CFR), Transportation (49 CFR), CSHASP, and the SSHASP.

B. Conform to all project, state, local, and/or federal hazardous materials regulations pertaining to the handling, transportation, and disposal of suspected asbestos contaminated materials.

END OF SECTION

SECTION 16

TRANSPORT AND DISPOSAL

PART 1 GENERAL

1.01 SCOPE OF WORK

A. VCI removed from residential, commercial, public, and industrial buildings in the Libby, Montana area shall be disposed at the Class IV Asbestos Landfill located at the Lincoln County Landfill.

B. Vermiculite-contaminated soils removed from yards, gardens, planters and other specific use areas on selected residential, commercial, public, and industrial properties in the Libby, Montana area shall be disposed at the mine site repository.

C. On a case-by-case basis, the government may allow disposal of VCI and related asbestos containing debris at the mine site repository.

D. On a case-by-case basis, the government may allow disposal of limited quantities of asbestos contaminated soil, demolition debris and other materials generated during contaminated soil excavation at the Class IV Asbestos Landfill.

E. The removal contractor shall be responsible for the transport and disposal of the VCI, vermiculite-contaminated soils, and other ACM generated during project activities.

F. The removal contractor will utilize only truck haulers licensed in the State of Montana.

G. The removal contractor shall maintain all operating records/ manifests required by the Federal Resource Conservation and Recovery Act (Public Law 94-580), DOT, the State of Montana and all other states to be traversed, as applicable. In general, the removal contractor shall comply with all applicable regulatory requirements, including federal, state or local laws, codes and ordinances which govern or regulate asbestos-contaminated wastes.

1.02 CONTAMINATED SOIL TRANSPORT

A. The removal contractor shall load, transport and dispose of all asbestos contaminated soils in a manner such that there is no release of asbestos fibers. Material generated from exterior removals shall be disposed of in accordance with applicable local, state and federal regulations. Demolition debris, trees, shrubs, pavements, spent PPE, and other materials generated with contaminated soil removal work shall also be disposed at the mine site repository or as directed by the Volpe Center.

B. Vacuum trucks and cabs of trucks used to haul contaminated soil shall be equipped with positive pressure units equipped with HEPA filters capable of preventing asbestos fiber migration into the truck cab during transport and disposal activities in regulated areas.

C. Beds of dump trucks used to haul contaminated soil shall be watertight and covered with tight fitting tarps secured in a manner that prevents release of asbestos fibers during transport.

D. Drivers of dump trucks not equipped with positive pressure units and HEPA filters shall wear PPE as determined by A&E H&S.

E. Disposal at the Class IV Asbestos Landfill, if allowed, shall be in strict accordance with the current revision of the Lincoln County Class IV Asbestos Landfill Operations Plan and all Addenda.

F. The removal contractor shall coordinate all disposal activity at the Class IV Asbestos Landfill with the government's landfill operator and the Volpe Center.

G. Following disposal, all trucks shall be thoroughly decontaminated before leaving the disposal location. Alternative measures, such as draping the truck body with polyethylene sheeting, may be approved by A&E H&S on a case by case basis, depending upon site conditions.

1.03 VCI TRANSPORT

A. VCI removed from residential, commercial, public and industrial buildings shall be stored in air tight steel roll-off containers or dedicated vacuum trucks.

B. VCI or other asbestos-contaminated material such not stored in roll-off containers shall be double wrapped in polyethylene sheeting, double bagged or drummed.

C. Vacuum trucks and cabs of trucks used to haul roll-off containers shall be equipped with positive pressure units equipped with HEPA filters capable of preventing asbestos fiber migration into the truck cab during transport and disposal activities in regulated areas.

D. Beds of dump trucks or pick-up trucks used to haul wrapped, bagged or drummed VCI shall be covered with tight fitting tarps secured in a manner that prevents release of asbestos fibers during transport.

E. Drivers of trucks not equipped with positive pressure units and HEPA filters shall wear PPE as determined by A&E H&S.

PART 2 EXECUTION

2.01 GENERAL

A. All transport and disposal of VCI, other ACM and demolition debris shall be performed in a manner such that there is no release of asbestos fibers.

2.02 LANDFILL DISPOSAL

A. The removal contractor shall load, transport and dispose of all VCI, removed wallboard, plaster, paneling etc. and spent PPE and other asbestos contaminated materials in a manner such that there is no release of asbestos fibers. Material generated from interior removals shall be disposed of in accordance with applicable local, state and federal regulations.

B. Disposal at the Class IV Asbestos Landfill shall be in strict accordance with the most current revision of the Lincoln County Class IV Asbestos Landfill Operations Plan and all Addenda.

C. The removal contractor shall coordinate all disposal activity at the Class IV Asbestos Landfill with the government's landfill operator and the Volpe Center.

D. VCI and other ACM contained in airtight roll-off containers shall be temporarily placed in a location designated by the government's landfill operator.

E. Roll-off containers and vacuum trucks shall be emptied in the misting tent, or other location approved by the Volpe Center, at the Class IV Asbestos Landfill.

F. VCI and other ACM not transported to the Class IV Asbestos Landfill in air tight roll-off containers shall be double wrapped in 6 mil polyethylene sheeting and placed directly in the operating landfill cell in a location designated by the government's landfill operator. Lift thickness for VCI and other ACM shall not exceed 18 inches.

G. ACMs contained within bags or drums shall be inspected as they are off-loaded at the active cell. ACMs in damaged containers shall be repacked in empty drums or bags as necessary.

H. ACM containers shall be placed on the ground at the disposal site, not pushed or thrown out of trucks, since the weight of the wet material could rupture the containers.

2.03 MINE SITE REPOSITORY DISPOSAL

A. The Government has constructed a transfer station referred to as the Amphitheatre area off of Highway 37, approximately 1½ miles up Rainy Creek Road leading to the abandoned vermiculite mine. Asbestos-contaminated soil and related materials removed from residential, commercial, public and industrial properties shall be transported by the removal contractor to the Amphitheatre area for temporary storage. The Amphitheatre area is equipped with personnel and equipment decontamination facilities and is operated by a separate government contractor on an as-needed basis. Stockpiled contaminated soil and related ACM is periodically moved to the abandoned mine by a separate government contractor for permanent disposal.

B. The removal contractor shall coordinate disposal of contaminated soil and related ACM at the Amphitheatre area with the Volpe Center. All disposal activity shall comply with established Amphitheatre operations protocols as required by the Volpe Center.

C. All trucks disposing contaminated soil at the Amphitheatre area shall be thoroughly decontaminated prior to leaving the area.

END OF SECTION

SECTION 17

SHOTCRETE

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The removal contractor will furnish all labor, materials, equipment and incidentals required to install shotcrete as indicated on the site-specific work plans.

1.02 SUBMITTALS

A. For structural applications only: Submit experience record in shotcrete work of each nozzleman and foreman to be employed on the project as specified.

1.03 REFERENCE STANDARDS

A. ASTM

1. ASTM C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete
2. ASTM C150 – Standard Specification for Portland Cement
3. ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

B. ACI

1. ACI 506R – Guide to Shotcrete
2. ACI 506.2 – Specification for Materials, Proportioning, and Application of Shotcrete
3. ACI 506.3R – Guide to Certification of Shotcrete Nozzlemen

C. AWWA

1. All Shotcrete shall conform to the requirements of AWWA D110.

D. National Ready Mixed Concrete Association (NRMCA) and Truck Mixer Manufacturer's Bureau (TMMB).

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. Contractor's Qualifications: Shotcrete construction shall be performed by an established contractor having previous experience with shotcrete.

B. For structural applications of concrete only: Foreman's and Nozzleman's Qualifications: Foreman supervising the placing of shotcrete shall have a minimum of 3 years experience as a nozzleman. Each shotcrete nozzleman shall have a minimum of 2 years experience on similar applications and shall be able to demonstrate by the tests specified in Paragraph 2.03C the ability to satisfactorily gun shotcrete of the required quality.

C. Independent Testing Laboratory

D. Shotcrete Quality: Slump shall be 4-inches for flat work and 2-inches for vertical work. Water shall be kept to a minimum to obtain shotcrete which is as dense and watertight as possible. The cement factor shall be between 7 and 8 (94 pound) sacks per cubic yard. Select proportions of ingredients to meet the design strength and materials limits to produce shotcrete having placability, durability, strength, appearance, and other required properties.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance, and manufacturer's service.

2.02 MATERIALS

A. Materials shall comply with this Section and any applicable state or local requirements.

B. Cement: Domestic portland cement conforming to ASTM C150, Type II. Air entraining cements shall not be used. Cements produced by a manufacturer that uses hazardous waste derived fuel as an energy source for its kilns shall not be used. Cement brand must be approved by the Engineer, and one brand shall be used throughout the work.

C. Aggregates: Maximum coarse aggregate size of 3/8 inch. Test aggregates for potential alkali reactivity.

D. Water: Potable water free of oil, acid, alkali, salts, chlorides, organic matter, or other deleterious substances.

2.03 MIXES

(A through E apply to structural applications only.)

A. Develop shotcrete mixes and their testing by an independent testing laboratory engaged by and at the expense of the removal contractor.

B. Proportion shotcrete mixes by pre-construction testing in accordance with ACI 506.2.

C. Compression Tests: Provide testing of the proposed shotcrete mixes to demonstrate compliance with the specified compression strength requirements in conformity with ACI 506.2.

D. Entrained air, as measured by ASTM C231.

1. If the air-entraining agent proposed for use in the mix requires testing methods other than ASTM C231 to accurately determine air content, make special note of this requirement in the admixture submittal.

E. Slump of the shotcrete as measured by ASTM C143.

F. Proportion admixtures according to the manufacturer's recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

PART 3 EXECUTION

3.01 PREPARATION

A. The removal contractor must inspect all areas where shotcrete will be placed to identify and protect existing utilities, pertinent features, and any other items that could be damaged by its application. The A&E will inspect removal contractor preparations to ensure that all necessary precautions are taken with regard to utilities and features prior to shotcrete application.

B. Remove all loose material, dirt, and mud from rock surfaces. Wet rock surfaces prior to shotcreting and remove all standing water.

C. For structural applications only: Determine, provide, and install accessories such as expansion bolts and adhesive anchors in conjunction with fittings and hardware to support the reinforcement from the rock surfaces providing the spacings and clearances indicated and prevent its displacement during the erection of the reinforcement and placement of shotcrete.

3.02 MIXING AND PLACEMENT OF SHOTCRETE

A. For nonstructural placement, the removal contractor must add fiber mesh to the shotcrete mix, in a proportion to be decided by the A&E.

B. Method of shotcreting shall be the wet-mix process.

C. For structural applications only: Vertical shooting wires shall be installed and tensioned to establish uniform and correct thickness of shotcrete. Shooting wires shall be spaced at 2 feet on center around the circumference. The final coat shall be applied true to shooting wires so as to form a cylindrical surface. Remove wires and fill low spots left by wires prior to final finishing.

D. The nozzle shall be held at such a distance and position that the stream of flowing material shall be, as nearly as practicable, perpendicular to the surface being covered.

For structural applications only: Remove rebound and overspray from rock substrate, shotcrete in place, and reinforcing prior to placing shotcrete. Should a deposit of rebound, overspray or sand be covered with shotcrete, it shall be cut out and replaced with proper material.

E. Velocity of material leaving the nozzle shall be uniform and such to produce a minimum of rebound. The surface to which shotcrete is applied shall be free from frost. No shotcrete shall be placed on days when the wind is more than 20 miles per hour or when moist inclement conditions prevail on the work surfaces.

F. The shotcrete mixture shall be such that once in place, the surface will have a rich glossy appearance. For structural applications only: In the event of sagging, the shotcrete shall be completely removed and the defective area replaced.

G. At the end of the day's work, or similar stoppage period, the shotcrete shall be sloped off at an angle of approximately 45 degrees. Before placing adjacent sections, the sloped portions shall be thoroughly cleaned and wetted by means of air and water blast.

H. All overspray will be removed by the removal contractor. All utilities will be protected during shotcrete activities.

I. Finishing Shotcrete

1. All shotcrete construction shall receive a wood float finish.

J. Curing Shotcrete (for structural applications only)

1. Curing shall be accomplished by keeping the shotcrete wet continuously for 7 days. If the lining is built up in coats, each time a new coat is applied, a new 7 day curing period begins, superceding the curing schedule on prior coats. Natural curing may be allowed if the relative humidity is at or above 85 percent.

2. If shotcreting is not started until the temperature is 40 degrees F and rising, and is terminated when the temperature is 40 degrees F and falling, no special provisions need be made for protecting the shotcrete against low temperatures. Shotcrete placed below these temperatures shall be protected in accordance with ACI 506R. Shotcrete shall not be placed on frozen surfaces. For structural applications only: Shotcrete with a strength lower than specified due to cold weather shall be removed and replaced with sound material.

K. Patching and Repairing Shotcrete

1. Dry patches, slugs, sags, sloughs, voids, sand pockets, honeycombing, or other defects shall be removed and repaired to the satisfaction of the A&E.

3.03 FIELD TESTING (FOR STRUCTURAL APPLICATIONS ONLY)

A. A minimum of one test panel for each 20 cubic yards of shotcrete, but at least one panel per shift, shall be made during the progress of the work. Additional panels shall be made if deemed necessary by the Engineer. The test panels shall be made from the shotcrete as it is being placed and shall, as nearly as possible, represent the material being applied. The method of making the test samples shall be as follows:

1. A rectangular frame of 4-mesh wire fabric 2-foot-6-inches square and 6 inches deep shall be secured to a plywood panel and hung or placed in the location where shotcrete is being placed. This form shall be filled in layers simultaneously with the nearby application. After 24 hours, the fabric and plywood back up shall be removed and the sample slab shall be sent to the testing laboratory. At the age of 7 days, nine 3-inch cubes or cores shall be cut from each sample slab and subjected to compression tests in accordance with current ASTM standards. Three cubes or cores shall be tested at the age of 7 days, three cubes or cores shall be tested at the age of 28 days, and three cubes or cores shall remain held in reserve.

2. All shipping and testing will be paid for by the removal contractor.

B. Test for slump and air content.

END OF SECTION

A&E Air Monitoring Frequencies

The following table shows 2007 frequencies for project task-based air monitoring performed by the A&E.

2007 Air Monitoring Frequencies			
Analytical Method		***PCM***	***AHERA***
Mine Road			
Clean Room		-	1/Week
Trailer Entrance		-	1/Week
Personal	Water Truck Driver	2/Month	-
	Operator	1/Month	-
	Laborer	1/Month	-
RI & Predesign Teams			
Ambient (CDM Office)		1/6 Months	-
Ambient (EPA Info Center)		1/6 Months	-
Predesign (Attic Entries)		1/6 Months	-
Attic Inspections (CSS)		1/6 Months	-
Soil Sampling (CSS)		1/6 Months	-
Landfill Asbestos Cell			
Personal	Laborer	Daily	
	Operator	Daily	
Clean Room			1/Month
Perimeter of exclusion zones			1/Month
Bulk Removal Sites			
Personal	Bulk Removal	1/Week	-
	Demo	Daily	-
	Detailing Attic	1/6 Months	-
	Wet Wipe/HEPA Vac Living Space	1/6 Months	-
Clean Room		-	1/Site
Excavation Sites			
Personal	Laborer	2/Month	-
	Water Hose Operator	1/Month	-
	Excavator Operator	1/Month	-
Personal	Haul truck Drivers	1/6 Months	-
Clean Room		-	1/Site
Perimeter of Exclusion Zones		-	1/Site/Day

PCM = Phase contrast microscopy, Method NIOSH 7400
AHERA = Asbestos Hazard Emergency Response Act, TEM performed by Method EPA 40 CFR Part 763 Final Rule

CDM

Memorandum

To: *John McGuiggin/Jim Christiansen*

From: *Tim Wall*

Date: *April 12, 2005*

Subject: *Small Scale Vermiculite Removals*

Background

As part of the ongoing removal activities for the Libby Asbestos Project, CDM Federal Programs Corporation (CDM) is tasked with providing design support and air monitoring services in accordance with the Final Draft Response Action Work Plan (RAWP) for the Libby Asbestos Project (November 2003) and the Pre-Design Inspection Activities Work Plan for the Libby Asbestos Site (November 2003).

The purpose of this memo is to present the current interior removal design process when Libby Vermiculite (LV) is identified in a living space of a house or commercial building, and propose an alternative interior removal process hereby defined as a Small Scale Vermiculite Removal (SSVR). CDM believes this alternate process will enhance project efficiency and productivity while ensuring that the removal is protective of public health and worker safety.

The goal of the SSVR is to provide a process for defining, characterizing, and planning the removal of a "small" spill of LV, from an identified and correctable source, without having to automatically clean the entire level of the house or commercial building.

Current Process

Currently, a pre-design inspection (PDI) is completed to determine specific interior and/or exterior removal activities required at each property. Property interiors are segregated per level, evaluated by visual inspection, and characterized with dust sampling. Results of this investigation are used to design and plan the removal activities for that property. Under the current process, if LV is observed leaking into any portion of an interior level, then the entire level requires a full interior cleaning and dust samples are not collected from that level. If LV is not observed, then two dust samples are collected from the level and analyzed per

Appendix B (Sampling and Analysis Plan for Indoor Dust) of the PDI Work Plan. If any one dust sample result is greater than the interior cleanup criteria of 5,000 structures per square centimeter (S/cm2), then the entire level is cleaned. If both dust sample results are lower than the interior cleanup criteria, then the level is not cleaned.

Proposed Alternate Process

Defining a SSVR Area

If LV is observed leaking into an interior level during a PDI, the following criteria must be considered in order to define the SSVR area:

- The boundaries of the SSVR area must be defined under the assumption that the dust sample collected from the SSVR area will exceed the interior cleanup criteria. This assumption is necessary to ensure that the defined SSVR area is sufficient to construct containment, safely access the material, and perform final clearance sampling in the event that the dust sample results are above the interior cleanup criteria.

- Existing boundaries, such as walls and other physical features, may be used to define the SSVR area. If the SSVR area is located in an open area with no existing physical boundaries, CDM suggests that the SSVR area be defined with a minimum size of 9 square feet (ft^2). This size is assumed to be the minimum area required to construct containment, access material, and perform final clearance sampling.

- The source from which the material is leaking must be clearly identified so that it can be addressed during either the PDI or subsequent removal activities.

Characterizing a SSVR Area

Once the boundary of the SSVR area is defined by the PDI field team, it must be characterized separately from the remainder of the level to determine removal activity options. One composite dust sample will be collected and analyzed from the SSVR area, per Appendix B of the PDI Work Plan (Sampling and Analysis Plan for Indoor Dust). The remainder of the level will be characterized separately per current PDI protocol (unless additional SSVR areas are identified).

Decision Criteria

The following paragraphs describe the various decision criteria that must be applied to the SSVR process.

If any one dust sample result collected from the remainder (excluding the defined SSVR area) of the level is above the interior cleanup criteria, then the entire level (including the SSVR area) will be contained, cleaned, and aggressively cleared as defined in the RAWP.

If both dust sample results collected from the remainder of the level (excluding the defined SSVR area) are below the interior cleanup criteria, then the SSVR dust sample will be evaluated.

If the SSVR dust sample concentration is greater than the interior cleanup criteria, then containment will be constructed; the area will be cleaned according to the current processes as defined in the RAWP, and aggressively cleared prior to returning the property to the owner.

If the dust samples from the SSVR area and the remainder of the level are both below the interior cleanup criteria, then no containment will be required, the spill will be removed, and air clearance sampling will not be performed.

Removal Methods

Three primary engineering controls are recommended for SSVRs: mini containments; wet methods; and HEPA vacuums may be used singly or in combination by the contractor to ensure that the surrounding area is not negatively impacted as a result of removal activities.

Advantages of Alternative Process Implementation

Based on previous PDI data, vermiculite insulation spills are typically confined to specific rooms or areas and not throughout the entire house. These areas with leaking vermiculite can typically be isolated from the remainder of the level for cleaning purposes. Implementation of small scale removal activities will greatly improve project efficiency by eliminating the need to clean an entire level due to visible vermiculite that has been shown, through dust sampling, to not impact the remainder of the level. Field observations and analytical data have found that small spills do not always impact the remainder of the level and can be easily addressed with simple housekeeping procedures.

Additional advantages of implementing the suggested process include:

- Improved efficiency through refinement of removal areas
- Improved productivity through reduced time of removal at properties only requiring SSVRs
- Eliminate unnecessarily requiring full mobilization of cleanup contractor
- Less disruption to the resident
- Immediate cleanup of small spill areas

Required Action

Upon Volpe and EPA approval, CDM will modify the Final Draft Response Action Work Plan for the Libby Asbestos Project and the Pre-Design Inspection Activities Work Plan for the Libby Asbestos Site to incorporate/amend according to the alternate process, and begin implementation of the revised process.

cc: C. Zamora
S. Supernaugh
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